THURSDAY, NOVEMBER 11, 1886

LETTERS AND JOURNAL OF W. STANLEY JEVONS

Letters and Journal of W. Stanley Jevons. Edited by His Wife. (London: Macmillan and Co., 1886.)

A STRIKING but sad book is this autobiography; for though "written to give the best idea of the character of the man in the various relations of life more than to recount scientific work," it is practically an autobiography: there is scarcely a critical remark upon his thoughts or conduct in it.

The family for many generations had been settled in Staffordshire. The grandfather came to Liverpool, and commenced business as an iron-merchant there, and his son Thomas, a man of ability in many ways, joined him in it. This was the father of William Stanley Jevons, who had, moreover, the almost invariable precedent of a clever man (*pace* Mr. F. Galton), viz. a clever mother, whom, however, he had the misfortune to lose at ten years old. She was the daughter of William Roscoe, author of the "Life of Lorenzo de Medici" and "Leo the Tenth." Another misfortune, from which, however, he learnt the value of money in a practical sense, befell him at the age of thirteen, when the firm of Jevons and Sons failed; and his grandfather, who died in 1882 at the advanced age of ninety-one, came to live with them.

A characteristic very marked, and to a marvellous extent affecting his whole subsequent life, was a bashfulness or "natural timidity of character which," his father wrote him, "is the worst, or perhaps I may say the only, weakness you have." This led to self-depreciation, and at school the French master complained that he was far too quiet and made no noise, and did not read above his breath. Shrinking from his companions and their fun, however, he early acquired the habit of directing his attention and mental powers at his will, and nothing tried his naturally passionate temper more than to be compelled to leave the pursuit of the moment while still engrossed in it. Reports of him as a scholar naturally kept continually improving, and, though laboriousness is throughout his characteristic, his sister writes in her diary that she saw in Stanley at the age of fourteen the dawnings of a great mind.

Botany and chemistry, in both of which he subsequently took honours, were the two sciences which attracted him first. The former was begun under the loving eye of his mother: the latter was the first that he took up at University College School, and "followed fiercer and fiercer till he gained the University gold medal."

He had decided at seventeen to go into a chemical manufactory at Liverpool, in order to remain near home; but before he had ended his last term of study at the University his wishes and plans were all upset by Profs. Williamson and Graham recommending him for the appointment of Assayer to the new Mint in Australia. He shrank from it as being too heavy a post for a youth of eighteen, and as going terribly against his wish to settle at home. But an income of 675*l.* a year was too good an offer to be refused. On June 29, 1854, not yet nineteen years old, he set sail for Sydney.

While at Sydney he attacked the Australian meteorology, and published his observations; more, as he explains, to show what phenomena had to be solved and what interesting connections of cause and effect might be suggested. Geology also, which he had commenced shortly before he left England, he there followed up. There he first suggested a collection of newspapers from all parts of the world as a curious exhibition; there also he heard of the death, after seven years of reviving prosperity in trade, of his father in November 1855. Though doing so well financially, he still cherished the feeling that he was losing time which he might put to better advantage. After four years he resigned his post, and on his return, *viâ* Callao, Panama, St. Thomas, Havanna, and several cities of the United States, he made his way up country past Minneapolis, to visit a brother who had gone out to settle there. Returning thence by way of Niagara and Montreal to New York, he landed at Liverpool, but soon went on to London and re-entered the University. He joined several senior classes in company with his younger brother, whose education he was then paying for. He had decided thenceforth to follow up political economy and mental philosophy.

His "Theory of Political Economy" was read as a paper but not "approved" by the British Association at Cambridge in 1862. It was published in 1871, and reached a second edition in 1879. Though it attracted the attention of some eminent foreigners, it was coldly received in England—the free use of mathematical symbols placing it above the heads of those practically engaged in commercial pursuits. In 1875, at the British Association meeting at Bristol, he read another well-known paper on the connection between sunspots and the price of corn—bad crops of the latter, we need hardly add, being followed by a high price and bad trade—and though he spoke at first very doubtfully of his theory, yet up to the time of his death, in 1882, he believed that a great revival of trade would take place almost immediately, to be followed by seven years of unprecedented prosperity, and he had speculated accordingly. Gold, however, alas, seems a more important factor than sunspots.

A more famous paper still was his "Coal Question," published in 1865. It was a question in which the whole nation took an interest, and it supplied a text for one of Mr. Gladstone's economical budgets. Accordingly it was discussed in every paper, political, economical, or social, and is perhaps better known now than any of his other writings.

His earlier writings had brought him in very little, and in 1863 he had accepted the not very lucrative post of tutor at Queen's College, Manchester. In 1866 he was appointed Professor of Logic and Mental and Moral Philosophy, and Cobden Professor of Political Economy, at 300*l.* a year. A thorough teacher, he was much liked by his pupils, never tiring of making them understand, and watching their careers in after life.

In December 1867 he married the daughter of Mr. J. E. Taylor, founder and proprietor of the *Manchester Guardian.* To her we are indebted for this well-arranged selection of letters.

In 1864 he published his first work on "Pure Logic," chiefly founded upon Prof. Boole's system. In 1865 he invented a logical machine or abacus which he

describes as working in a few moments any logical problems involving no more than four distinct terms or things. It was like a small piano, three feet high, with twenty-one keys. A second book upon logic was published in 1869, just after this had been made to work correctly, entitled "The Substitution of Similars," containing a sketch of the fundamental doctrine of his great work, "The Principles of Science," which was not published in full till 1874, but reached a second edition in one volume in 1877.

In 1870 his "Elementary Lessons in Logic" appeared in Macmillan's series of science class-books, followed in 1876 by the "Primer of Logic," one of the same publishers' more elementary series; and in 1880 "Studies in Deductive Logic" for students desiring a more thorough course of logical training.

In 1868 he had prepared three articles attacking J. S. Mill's system of logic. They were declined at first, but three years afterwards, soon after the death of Mr. Mill, they were accepted by the *Contemporary Review*. It is curious to see two such mighty champions of such a learned science referring their differences to an uneducated public and to their instinctive logic!

Though sorry on many accounts to leave Manchester, his heart had never left London and its University, to which he returned in 1876 as Professor of Political Economy. In that year he boldly read a paper laying it down that the United Kingdom Alliance was the worst existing obstacle to temperance reform in the kingdom—driving the enemy to a man into fierce opposition.

His first illness through over-work had occurred in 1869, and from that time his letters in large proportion are from various places — Norway was his favourite resort—to which he had been driven to regain strength. Trip after trip was taken, but with no permanent effect. As soon as he returned he again overwhelmed himself with work, involving too great tension of the brain. The labour especially of taking his class when out of sorts was a "painful" labour to him. To relieve himself from this he resigned his Professorship in 1880, and in 1882, after two years more of work at home, but still at high pressure, a plunge into the sea was too sudden a chill for his enfeebled frame, and insensibility and death were the sad result, at the prime age of forty-six.

One cannot help sorrowfully noting how his childish bashfulness was the cause of his early death. It led to unsociability and abstinence from recreation. Instead of rejoicing in his strength, he shunned his companions, and persuaded himself, moreover, that it was his duty to do so, though he bitterly regrets it afterwards, one result being an inability to speak in public and communicate his ideas as he would wish. The ardent cultivation of his many talents, again, increased a feeling of superiority, yet often left him low-spirited. In some it might have brought carelessness and improvidence, but in Jevons it was attended by a feeling of responsibility almost religious. At twenty-three he threw up his easy and lucrative post at the Sydney Mint in obedience to this feeling, and, later on, he resigned one laborious duty only to buckle to another, and under such labour his life was quenched.

GENERAL PATHOLOGY

An Introduction to General Pathology. By J. B. Sutton, F.R.C.S. (London: J. and A. Churchill, 1886.)

UNTIL recently, pathologists have confined their attention to studying the processes of disease in human beings, and but little effort has been made to take advantage of the vast field of material presented by the animals which die in the Gardens of the Zoological Society. Since 1878 the author has systematically examined the bodies of 12,000 animals and of over 800 still-born and immature fœtuses; and from this vast stock of material he has, for the purposes of the present work, selected, from all parts of the animal kingdom, striking examples which illustrate the main pathological and physiological processes of life. The same principles govern both, and processes which in one group of animals are the cause of disease, in another, owing to anatomical differences, habits of life, and surroundings, have no such influence. Moreover, pathological defects are frequently inherited, and become looked upon as racial peculiarities. Thus the horns of the Ungulata, the curved canines of the Babiroussa, the atrophied right ovary and right carotid artery in many birds, the large third with the small second and fourth metarcarpals of the horse, are now persistent, but were probably originally accidental and pathological.

The degree of development of the muscular tissue of the gizzard of a bird is dependent upon the nature of its food. The herring-gull of the Shetland Islands changes its food twice every year—in the summer living on grain, when its gizzard is of the granivorous type, and in the winter on fish, when the gizzard reverts to the carnivorous condition. The same variations have been artificially produced by varying the food of sea-gulls, pigeons, ravens, and owls. While excessive function is the great cause of hypertrophy of organs, deficient usage is the determining factor in the abnormal overgrowths of hair, nails, beaks, and teeth. Rodents in captivity frequently require their teeth to be artificially shortened in order to avert the fatal effects of excessive overgrowth.

Monkeys, when in confinement, frequently die with symptoms of more or less complete paraplegia, which has recently been shown to be due to an overgrowth (frequently rickety) of the vertebræ near the intervertebral lamellæ. This gradual compression of the cord also occurs in tigers, lambs, bears, and others. These facts observed in animals throw light upon the agonising pains of mollities ostium, which are doubtless in like manner due to compression of the cord and nerves, which is permitted by the softening of the bones which the disease causes.

Metschnikoff's definition that inflammation is a struggle between irritant bodies and white blood-corpuscles is adopted. Illustrations are given showing the white corpuscles surrounding and digesting micro-organisms and other foreign bodies, or dying in the attempt to do so. When the tails and gills of larval batrachians are being absorbed, numerous amœboid cells can be seen containing fragments of nerve-fibres and muscle.

Our present knowledge of the nervous system quite fails to offer any explanation of the experiment which the author performed by transposing the median and ulnar nerves in

a cat. The two nerves were divided about the middle, and the distal end of the median was united to the proximal end of the ulnar, and *vice versâ*. Union occurred: sensation and motion returned in six weeks. The cat regained complete use of the limb, and did not appear to suffer any inconvenience. It would be of great interest to repeat the experiment by attaching the proximal end of the median to the distal end of the ulnar, but to prevent the other ends from uniting. Would the result be an unimpaired function of the median nerve, transmitted from the portions of the brain and cord formerly associated with the function of the ulnar?

The classification of the cysts and neoplasms of the animal kingdom are illustrated by many typical examples. The teratomata are fully discussed, and it is shown that they almost invariably occur only in spots where the epi-, meso-, and hypo-blastic layers have been temporarily but directly in continuity with each other. Thus præsacral tumours are associated with the obsolete neurenteric canal; pituitary tumours with the canalis craniopharyngeus (a canal through the floor of the basisphenoid), lingual dermoid cysts with the ductus thyreoglossus (a canal running from the basihyoid to the foramen cæcum of the tongue), and ovarian dermoid cysts with the obsolete Müllerian and Wolffian ducts. The predisposition of obsolete ducts to disease has for some time been recognised, but the close relationships of teratomata to such ducts is a more recent piece of work.

The novel illustrations of the leading pathological processes make the work one of extreme interest, and we heartily congratulate the author on the good use to which he has turned his exceptional opportunities.

PLANE GEOMETRY

The Elements of Plane Geometry. Part II. (corresponding to Euclid, Books III., IV., V., VI.). (London: Swan Sonnenschein, 1886.)

THIS book contains a revised edition of Books III., IV., V., of the "Syllabus of Plane Geometry" drawn up by the Association for the Improvement of Geometrical Teaching, with demonstrations of the propositions, and an excellent, though limited, collection of suitable exercises. If nothing else than these two parts had been the outcome of the movement first set on foot in our columns, the Association would have amply justified its formation. Much difference of opinion has prevailed as to the desirability or expediency of the Association producing such a work as this. The late Mr. Merrifield for some years strenuously opposed any such proceeding, but at the annual meeting of 1881 he expressed himself as "now satisfied from the experience which he had had in dealing with the examining bodies that they would not get their work really adopted by the public until they had a text-book. Everywhere he was met with the impossibility of wading through a dry Syllabus. Nobody who was not thoroughly versed in mathematics could judge whether there was any real possibility of teaching from the Syllabus at all." Circumstances appear to have compelled the Association at last to take the field with demonstrations put forward by a selected committee of its members: a principal reason being that the Association was bound to help teachers. The plan of teaching the Syllabus without giving written proofs was found to succeed so long as the teaching was confined to the earlier parts of the subject, but when the later books were reached it was found necessary to give formal written proofs for subsequent reference (Report, 1881, p. 30).

Some teachers who wish for the more copious introduction of modern ideas and methods into the very elements may not consider the work of the Association as satisfactory as could be wished, and may think there is very little of the influence of the aforesaid modern ideas in the Syllabus, yet even such admit, and express satisfaction in making the admission, that "the use of the Syllabus has spread pretty widely, and it is to be hoped that it will continue to do so" (Prof. Henrici, British Association address, NATURE, vol. xxviii. p. 500). It is to be borne in mind that the Professor hardly gave the Syllabus a fair trial, though he says that when it appeared "I resolved to give it a thorough trial, and took the best means in my power to form an opinion on its merits by introducing it into one of my classes. The fact that it did not quite satisfy me, and that I gave up its use again, does not of course prove that it fails also for use in schools, for which it was originally intended."

These students had, we assume, to take down in writing the Professor's proofs, and it is not as agreeable work to "grind up" manuscript as it is to read a printed page; then there would be by-gone remains of the old text-book haunting the students' brains, want of familiarity with the Syllabus possibly on the teacher's part, and finally shortness of time over which the trial extended. At this point we may cite some remarks by the late Dr. Todhunter, which make as much for Syllabus upholders as for Euclidians. "It will be hard to secure that pupils shall be selected of equal power, and be trained with equal assiduity; and then if our teacher is to try various methods he is liable, since he knows that a controversy is now existing as to the result, to deviate from impartiality in his treatment of the rival methods. Moreover, there may naturally arise some disagreement as to the means to be used for testing the value of the results, and as to the accurate application of the principle which may be finally adopted for this end" ("Conflict of Studies," &c., p. 156). A fair trial would be to take two classes of students of as nearly as possible equal mental calibre, and with equal want of acquaintance with geometry, and to take each through the respective courses for the same time, and to take care that each teacher should be equally skilled and acquainted with his author and equally enthusiastic, for, as our essayist just cited writes, "if the teacher is only languid without being positively hostile, his real sentiments are soon discovered: hypocrisy has but a slender chance of deceiving school-boys" (p. 164). But such a fancy is Utopian; the hope of the Association at first lies in such far-away parts as the Cape and India, where its work is being taken up by enthusiastic and able teachers.

We have read the proofs, and believe them to be thoroughly accurate; there is also a careful avoidance of all looseness of language. Dr. Todhunter's "deliberate judgment" was that "our ordinary students would suffer very considerably if instead of the well-reasoned system of Euclid any of the more popular but less rigid manuals were allowed to be taken as a substitute" (p. 168). So

fearful was he of looseness or slipshoddiness that he more than once returns to this matter, and upon this very point of an Association text-book writes as follows:—"There are various considerations which seem to me to indicate that if a change be made it will not be in the direction of *greater rigour*" (p. 172). He owns himself once to have been in favour of *hypothetical* constructions, but that he had subsequently seen reason to alter his opinions: in many places in his essay he shows that he has not renounced *hypothetical* statements. His idea of an Associationist seems to have been that he is a being who tries to evade the difficulty of passing a pupil in geometry by asking for a less stringent text-book than that of Euclid.

It is vain to wish for the verdict of such able critics as De Morgan and Todhunter on the work before us, but we feel sure that the former would not have written concerning it "Non est geometria," nor the latter have found it wanting in Euclidian rigour.

As to this matter of a different order from Euclid's sequence we cite with cordial approval the following remarks of a writer in our columns (vol. xxxiv. p. 50):—"We believe that those who have most carefully considered the question of a rival order of sequence of geometrical propositions would agree that the best order in a logical arrangement does not seriously *conflict* with Euclid's order, except by simplifying it. Rather, by bringing the proofs of each proposition nearer to the fundamental axioms and definitions than Euclid does, it renders less assumption of previous propositions necessary for the proof of any given proposition. It stretches the chain of argument straight instead of carrying it round one or many unnecessary pegs."

The influence which the Syllabus has had upon modern editions of Euclid is patent to any reader of the works in question. And now, little book, that the Association has at the end of days sent forth on to (it may be) tempestuous seas, we wish thee *bon voyage!*

OUR BOOK SHELF

American Journal of Mathematics. Vol. viii. No. 4. (Baltimore, August 1886.)

THE number opens with a memoir, by M. Poincaré, "Sur les Fonctions Abéliennes." The author gives here a *résumé*, with additional details, of a demonstration and generalisation of two of Weierstrass's theorems, which he had previously published in the *Proceedings* of the Mathematical Society of France (tome xii. p. 124). He then extends a theorem of Abel's from plane curves to surfaces, and refers, for fuller details, to a crowned memoir of M. Halphen's, "Sur les Courbes gauches algébriques." He next discusses some properties of "fonctions intermédiaires," using the term in the sense given by MM. Briot and Bouquet. This memoir occupies fifty-four pages. The second paper, on "A Generalised Theory of the Combination of Observations so as to obtain the best Result" (24 pp.), is by the editor, Prof. Newcomb. A very valuable article, with important practical applications. The final article (22 pp.), "On Symbolic Finite Solutions and Solutions of Definite Integrals of the Equation—

$$\frac{d^n y}{dx} = x^m y,"$$

is by Mr. J. C. Fields. It discusses finite solutions analogous to the symbolic solutions of Riccati's equation.

A Sequel to the First Six Books of the Elements of Euclid; containing an Easy Introduction to Modern Geometry (with numerous Examples). By John Casey, LL.D., F.R.S. (Dublin: Hodges, 1886.)

THIS is the fourth edition of a book which has been received with warm approval by English and Continental geometers. The first eight sections present no notable changes from the corresponding sections in the last edition. In our previous notice (NATURE, vol. xxix. p. 571) we remarked that the author was "not so well up in the literature of the modern circles as he might be." This reproach is quite removed in the present edition. Indeed in this direction the author has himself now done excellent yeoman's service. The "supplementary chapter" of fifty-eight pages gives an admirable account of this modern branch in six sections. The first section states and illustrates the theory of isogonal and isotomic points, and of anti-parallel and symmedian lines. The second discusses "two figures directly similar" in homothetic figures. The third section is headed "Lemoine's and Tucker's circles." The fourth discusses the "general theory of a system of three similar figures." The fifth gives "special applications of the theory of figures directly similar," more particularly with reference to Brocard's circle and triangles. In the sixth section on the "theory of harmonic polygons," the author, starting from Mr. Tucker's extension of the Brocard properties to the harmonic quadrilateral, and Prof. Neuberg's continuation of the same, gives his own beautiful generalisations to the harmonic hexagon and other allied polygons. This latter extension has been made the subject of a communication by MM. Tarry and Neuberg to the French Association meeting at Nancy in August of the present year. The paper, which is not expected to be published until April 1887, contains a complete generalisation of points of Lemoine and Brocard, and the modern circles cited above for polygons and polyhedra.

The success of the "Sequel" is due to the fact that the author and the subject are exactly suited to each other: the union is a most harmonious one, and the result is a work indispensable to all lovers of geometry.

Geometrical Drawing for Army Candidates. By H. T. Lilley, M.A. Pp. x., 54. (London: Cassell and Co., 1886.)

IN a short introduction to this little work the author gives some useful advice to those beginning practical geometry, and rightly lays stress on the proper method of handling instruments, and on a good style of working.

The book contains altogether 300 problems in plane constructive geometry; they are nearly all straightforward and easy, but 180 of them are specially indicated as forming, according to the author's experience, a suitable first course for the majority of students.

The problems are conveniently grouped together, and hints are given in aid of the solution of typical ones, and of those presenting extra difficulty. Beginning with the construction of scales, we have the usual series on polygons, proportionals, equivalent areas, and, in conclusion, several cases of circles touching other circles or given lines.

As a book of examples this collection seems likely to prove useful in class-teaching. But in order to insure sound instruction, much that is not contained herein will have to be provided for the student. Thus in the notes to the problems before us no reasons are given or indicated for the various steps in the constructions, and there is no distinction drawn between those methods of construction which are exact, and those which do not admit of proof.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

The Enormous Loss from Ox-Warble

I HAVE read Mr. John Walker's remarks on "warbles." This is one of the many important subjects to which Miss Eleanor Ormerod has lately drawn attention. I can readily believe that there is a loss of two to three millions to the country through the ravages of this fly, but such statements, it must be remembered, should be qualified by the thought that it might cost two or three millions to protect all the cattle of this country against such attacks. The labour would be great, the vigilance would entail higher-classed stock-men, in almost all cases with higher wages, for you cannot get our labourers, dairy-men, and bailiffs even, to attend to such matters without great difficulty. The loss does not, I think, fall upon farmers, unless it is from the irritation to the cattle when they hear the buzz of the fly meditating her attack.

As to the damage to the hide, I never, in my experience, heard a butcher or dealer make warbles in the hide a pretext for offering one shilling less for a bullock. They take no notice of them at all; and, if the maggots injure the hide, this is a matter for fell-mongers and tanners, rather than for farmers. This is one of the cries emanating from the scientific friends of agriculture which it is well to listen to. It will probably gain the ear of only a select circle of agriculturists, because, to use a very homely phrase, "the game is scarcely worth the candle." Animals pass through the market too rapidly, and the prices asked and given are so approximate only to the absolute value, that a few warbles in the skin do not in the least influence the selling price. Still, anything which can be shown to influence the comfort of live stock or the value of their products must be considered as worth attention.

JOHN WRIGHTSON

College of Agriculture, Downton, Salisbury, October 31

"Lung Sick"

MR. H. RIDER HAGGARD, in his excellent novel, "King Solomon's Mines," has the following passage. He is speaking of Zulu oxen, and says:—

"As for 'lung sick,' which is a dreadful form of pneumonia very prevalent in this country, they had all been inoculated against it. This is done by cutting a slit in the tail of an ox, and binding in a piece of the diseased lung of an animal which has died of the sickness. The result is that the ox sickens, takes the disease in a mild form, which causes its tail to drop off, as a rule about a foot from the root, and becomes proof against future attacks."

Presumably this account is *bonâ fide*. It will be gratifying to me, then, if any of your correspondents will kindly explain how it is that the virus, which has not been weakened by cultivation, produces the disease in a mild rather than in a virulent form.

E. J. DUNGATE

6, Marchmont Road, Edinburgh, November 1

The Beetle in Motion

WITH reference to Prof. Lloyd Morgan's letter in last week's NATURE (p. 7), the following passage, which occurs in an interesting chapter on "Motions of Insects" in Kirby and Spence's "Entomology," may be quoted:—

"In walking and running, the hexapods, like the larvæ that have perfect legs, move the anterior and posterior leg of one side and the intermediate of the other alternately."

This passage is in complete accord with the observations of your correspondent. C. J. G.

November 9

Meteors

YESTERDAY (November 2), about 8.8 p.m., I chanced to see here a meteor that, I think, deserves record, especially if my report of its position in the sky can be compared with that of some one who observed it at another place.

Returning from Oxford, I was about half a mile east of Combe Church, on the lofty plat that is the remnant of Combe Common. "Stepping westward," I was startled by a sudden splendour, flooding with light the moonlit heaven. This splendour was above me and before me; it was a little on my left. A large meteor was rapidly descending, at an angle of 60° or 70°. Not much east of it shone the half-orbed moon; but little west of it stretched the eastern branch of the Milky Way's western termination. When it had traversed about three-fourths of the distance between its apparent starting-point and the undulating ground beneath, it swelled out for a moment grandly, and, before it burst, displayed a globe at least as big as the sun, and of about the same hue, though not of dazzling lustre. After it had vanished, its track was marked for a second or two by a brilliant trail, which, in the light of the neighbouring moon, sparkled with all the tints of the rainbow, and resembled a gorgeous shower of precious stones.

JOHN HOSKYNS-ABRAHALL

Combe Vicarage, near Woodstock, November 3

I HAVE read Mr. Murphy's letter (NATURE, November 4, p. 8). At the same time as Mr. Murphy saw a large meteor (October 31, 8.25 p.m.) I also saw an immense one coming from the same portion of the sky, and travelling west. It disappeared behind a cloud. There was a loud rushing noise.

E. PARRY

Dinorwic Quarries, Llanberis, North Wales

INFLUENCE OF WIND ON BAROMETRIC READINGS

I AM glad to see (NATURE, vol. xxxiv. p. 461) that the Scottish Meteorological Society recognises the importance of the effect of wind upon the barometer. I assume that the gradient, the density, and all other sources of error had been fully corrected for before concluding the existence of the large effect attributed to the wind on Ben Nevis.

There certainly is a purely local and dynamic effect of the wind on the barometer due to the exposure, and for which there must be found some method of correction or elimination before we can proceed much farther in barometry: this effect has been independently reasoned out by G. K. Gilbert ("A New Method, &c.," 1883), and has been discussed by Prof. H. A. Hazen (*Annual Report*, C.S.O., 1882, p. 897), and by Mr. Clayton and others in recent numbers of *Science*, but its existence was long since demonstrated by Sir Henry James (*Transactions* Roy. Soc. Edinburgh, vol. xx., 1853), whose memoir seems to have been quite lost sight of by meteorologists.

The suction of wind on tubes, cowls, and chimneys was investigated by Ewbank (*Journal* of the Franklin Institute, 1842), Wyman (*Proceedings* of the American Academy, Boston, 1848), Fletcher (*B.A.S. Reports*, 1867 and 1869), Magius (Copenhagen, 1875?), Holten (Copenhagen, *Oversigt Vidensk-Selskabs*, 1877), and was used by Hagemann as the basis of his anemometer; it was Hagemann's memoir (Copenhagen, 1876, translation will appear in *Van Nostrand's Magazine*, Dec. 1886) that suggested a method of determining and correcting for the amount of this important effect, whose existence had long been known to me. This method is sketched out in the *Annual Report* of the Chief Signal Officer, U.S.A., 1882, p. 99, where I state that a close determination simultaneously of both dynamic wind-pressure and static air-pressure is probably attainable by exposing above the roof, side by side, a Pitot tube facing toward the wind and a vertical tube over which the wind blows. Close the lower ends of these tubes and place within each an aneroid barometer, and the latter will record respectively the static pressure plus the effect of the wind-velocity and the static pressure minus the wind's effect. A stop-cock, cutting off at will communication between the aneroids

and the exposed mouths of the tubes, allows one to catch the influence of any gust and read the pressure at leisure.

The theoretical problem of the precise mechanical action of these tubes, especially that which Hagemann calls a Magius tube, *i.e.* one across which the wind blows at right angles, will, I hope, prove attractive to the mathematical physicists of England. Some interesting experimental work by Robinson will be found in *Van Nostrand's Magazine*, vol. xviii., 1878, p. 255, and xxxv., 1886, p. 89. A small closed room with only a chimney flue opened, such as usually obtains at the mountain stations of meteorologists, is virtually a Magius tube, and the barometer within must, under favourable conditions, show a depression depending on the so-called suction or draft up chimney. The direction of the wind combines with the structure of the building and the aspect of the various doors and windows to modify the influence of the force of the wind; the sluggishness due to the close cisterns, and the pumping due to the inertia of the liquid of ordinary mercurial barometers, further complicate the phenomena of suction during gusty winds, so that a simple general rule for correcting the observed barometric readings becomes impracticable, but the use of aneroids within closed Pitot or other tubes, with air-tight stop-cocks as above, simplifies the wind's action, and allows of its measurement at definite moments.

The distribution of pressure over the face of a large building fronting the wind, and in some part of which is the window of the room containing the barometer, is approximately known from Curtis's and Burton's measurements for a thin flat plate.

The location of each station with respect to mountains or other orographic features has also an influence on the pressure, which will still remain to be investigated; thus, on the leeward side there is a diminution, and on the windward side an increase of pressure, but this may be generally inappreciable.

It may also be mentioned in this connection that in delicate barometric measurements, such as those made by the International Bureau of Weights and Measures, it is important to prevent even the slightest currents from blowing across the open end of the siphon tube.

The suction effect of wind blowing over chimneys surmounted by cowls of different shapes was under investigation from 1878 to 1881 by a special committee of the Sanitary Institute, but, so far as I can learn, their experiments were never completed. Lord Rayleigh also read a short paper on the same subject at the meeting of the British Association in 1882, but as I do not know of its publication, I take this opportunity to express the hope that he will give meteorologists both a theoretical and experimental exposition of the action of the Pitot, the Magius, and the reversed Pitot tubes, and a suggestion as to the best method of determining, by means of stationary apparatus, the static pressure within a mass of moving air.

CLEVELAND ABBE

Washington, October 23

M. PASTEUR'S TREATMENT OF RABIES

AT the meeting of the Paris Academy of Sciences on November 2, M. Pasteur submitted a further communication on the results hitherto obtained from his method of treating hydrophobia by inoculation, which has now been in operation for a twelvemonth. The paper is divided into three parts, the first giving the statistical details brought down to the present date, the second describing certain modifications in his method as originally applied, the third giving the results of fresh experiments on animals. Up to October 31 as many as 2496 persons were inoculated at his Paris establishment, and at first the treatment was uniform for all alike, whatever their age, sex, or other varying conditions. Of the total number 1726 were from France and Algeria, 191 from Russia, 165 from Italy, 107 from Spain, 80 from England, 57 from Belgium, 52 from Austria, 22 from Roumania, 18 from the United States, 14 from Holland, the rest from various other parts of Europe, besides 3 from Brazil and 2 from British India. Of 1700 French patients, apart from 2 who arrived too late, 10 only succumbed, whereas of the small minority not treated at the laboratory as many as 17 died in the same period in the rest of France, while for the last five years the average yearly mortality from hydrophobia was 11 in the Paris hospitals alone. Last year it rose to 21, but since November 1885, when the new system was introduced, 2 only died, and these had not been inoculated, besides a third who had been imperfectly treated. Most of those who perished were children bitten in the face and subjected to the simple treatment, which experience now shows to be insufficient in such cases.

A first lesson on the necessity of stronger doses was taught by the 19 Russians bitten by a mad wolf, one of whom died while under treatment, and two others shortly after. In consequence of these deaths the 16 survivors were subjected to a second and third treatment with the strongest and freshest virus from the spine of the rabbit of 4, 3, and 2 days' standing, whereas, for the milder treatment, virus from 14 to 5 days' old had alone been used. To these repeated treatments should most probably be attributed the recovery of these Russians, who are reported to be all still in excellent health.

Encouraged by these results and by the fresh experiments described further on, M. Pasteur modified his treatment, making it at once more rapid and more active for all cases, and even still more energetic for bites on the face, or for deep and numerous lacerations of exposed parts of the body. In such cases the inoculations are now hastened, in order to arrive more promptly at the freshest virus. Thus, on the first day, virus of 12, 10, and 8 days will be used at 11, 4, and 9 o'clock; on the second day that of 6, 4, and 2 days, at the same hours; on the third, virus 1 day old. Then the treatment is repeated: the fourth day with virus 8, 6, and 4 days old; the fifth with that of 3 and 2 days; the sixth with that of 1 day; the seventh with virus of 4 days; the eighth with that of 3; the ninth that of 2; the tenth with that of 1 day.

If the bites are not healed, or the patients arrive somewhat late, the same treatment may be renewed at intervals of two or a few days for four or five weeks, which are the critical periods for children bitten in the face. This system of vaccination has been in operation for the last two months, hitherto with excellent results, as shown by comparing the case of the six children who perished under the mild treatment, with that of ten others also seriously bitten last August, and subjected to the more energetic treatment, and all of whom were doing well on the first of this month. This new system requiring an increase of the staff, M. Pasteur and his assistant, Dr. Grancher, have been aided for some time past by Dr. Terrillon, Dr. Roux, Dr. Chantemesse, and Dr. Charrin.

With regard to the fresh experiments on dogs, an objection to the inoculation of human beings after being bitten might be raised on the ground that the immunity of animals treated before being bitten had not been sufficiently demonstrated after their undoubted infection by the virus. In reply to this objection M. Pasteur points to the immunity of dogs after trepanning and intra-cranial inoculation with the virus of ordinary street rabies. Trepanning is the surest method of infection, and its effects are constant. The first experiments on this point, dating from August 1885, had but partial success. They were resumed during the last few months, with certain modifications which produced the best results. The vaccination is begun the day after inoculation, and proceeded with rapidly, the series of prophylactic virus being all administered within twenty-four hours and even in a shorter period, and then repeated

once or twice at intervals of two hours. The failure of Dr. Frisch, of Vienna, in experiments of this kind is due to the slow process of vaccination adopted by him. Success can be secured only by the rapid method here described. The immunity conferred under such conditions is the best proof of the excellence of this method.

REPORT ON THE CHARLESTON EARTHQUAKE[1]

THE earthquake of August 31, which, from the locality in which its greatest power was displayed, will generally be known as the "Charleston Earthquake," was, perhaps, the most notable disturbance occurring within the limits of the United States of which we have any knowledge. It is entitled to this rank both on account of the wide area over which it was distinctly felt, and of the magnitude of the disaster which it caused in the immediate vicinity of the point of maximum intensity.

The earthquake consisted of a series of seismic disturbances which began in slight but distinctly noticeable tremors occurring on August 27 and 28, at the town of Summerville, about twenty-five miles north-west of Charleston, South Carolina.

The shock of greatest violence occurred a little before ten o'clock on the night of Tuesday, August 31. It was followed by several of lesser magnitude on that night, and during the succeeding three or four weeks. The great shock began in the city of Charleston within a few seconds of 9.51 p.m., 75th meridian time. The duration of the vibratory motion of the earth at that point was probably about forty seconds; the motion at first being moderate, but increasing with great rapidity during the last ten or fifteen seconds.

All of the loss of life and property during the whole series of disturbances is to be attributed to this first shock. Five minutes later another occurred, and ten minutes later still another; the latter being of considerable violence, but neither alone would have done any damage. The same may be affirmed of the succeeding series of disturbances, which, with greatly diminished intensity and at increasing intervals of time, continued to maintain the conditions of alarm and terror into which the people of the afflicted locality were naturally thrown by the first disturbance. Although some injury to buildings resulted from these after shocks, it is tolerably certain that in all such cases displacement and fracture had taken place in the great shock; the lesser disturbances simply finishing what had then been nearly completed.

The origin of the disturbances, appears to have been somewhere below a point fifteen or twenty miles north-west of Charleston; that is, in the neighbourhood of the town of Summerville. A chart of provisional co-seismal lines drawn by Mr. Hayden of the Geological Survey, and published in *Science* for September 10, seems to locate this centre somewhat further north than the point indicated above. At the time of its construction, however, information from many points was lacking, and that which was at hand was admittedly doubtful in some degree.

Reference is made later to the iso-seismal chart which accompanies this Report, and which indicates that the origin was near the point referred to above. Strong proof of this is also furnished in the intensity and character of the disturbance as shown by the effects which were still visible when an examination was made a few days after the principal shock. The appearance of the brick piers upon which many houses in Summerville rest was such as to justify the conclusion that the principal component of the motion at that point was vertical, and it was evident that the destruction of buildings was much less than would have resulted from a horizontal movement equal to that which had taken place in Charleston and elsewhere in the neighbourhood.

[1] By Prof. T. C. Mendenhall, Assistant. From the *Monthly Weather Review*, U.S. Signal Service, August 1886.

Another fact of importance is that in the vicinity of Summerville the disturbances preceding that of August 31 took place, and here they have been most numerous and most persistent. Indeed, at the present writing, nearly a month after the first perceptible shock, they still occur at irregular intervals varying from a few hours to a few days. Only the most violent of these have been felt as far as Charleston.

Nearly all the movements in Summerville and vicinity have been accompanied by, and, indeed, generally preceded by, a low rumbling sound, lasting one or two seconds, and not unfrequently this sound, always unmistakable in its character, was neither accompanied nor followed by a perceptible movement. This was a common occurrence at Summerville and in the immediate vicinity, and it was found that among several observers there would be no agreement upon the direction from which the sound appeared to come.

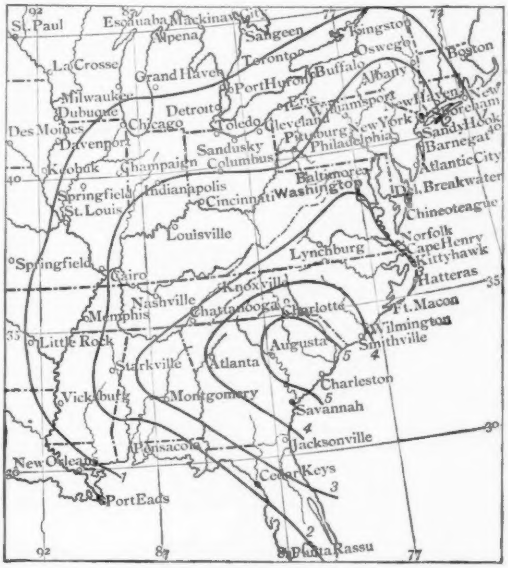

Chart of iso-seismal lines.

At a distance from ten to fifteen miles from Charleston in the direction of Summerville some of the most curious and interesting effects of the disturbance were to be seen. These were the "sand craters" and crevices, out of which extensive eruptions of sand and water had taken place on the night of August 31. The craters thus formed varied in size from an irregular oval, twenty-five feet long by fifteen feet wide, to shallow cones not over an inch in diameter and beautifully symmetrical in form. The area surrounding these openings was generally flooded with sand, often acres in extent, to a depth varying from a fraction of an inch to fifteen and eighteen inches. About the larger cavities the average depth was probably not less than six inches, and the area covered often an acre or more. The flow of sand was unquestionably only an incident to the outflowing of vast quantities of water, the greater part of which disappeared within a few hours after its appearance. The few crevices or "cracks" in the earth which were found were in character and origin similar to the "craters," being long and narrow openings, through which water with sand had been ejected.

It was difficult, in fact quite impossible, to obtain reli-

able information concerning the nature of this phenomenon at the moment of its occurrence. The locality in which it was principally exhibited is near a station on the South Carolina Railway, between Charleston and Summerville, known as "Ten-mile Hill." It is thinly populated, and almost entirely by negroes. Several persons who pretended to have been eye-witnesses of the outburst gave widely different testimony as to its character. According to one account, the water and sand from one of the "geysers" spouted to a height greater than that of a telegraph pole and continued to flow for four or five hours. Another, and apparently an equally credible witness, declared that the stream reached a height of six or eight feet, and that the flow continued four or five minutes. The latter statement is probably nearer the truth than the former.

A few instances of sand eruptions were found in the city of Charleston, and a few also at Summerville, and at the latter place water continued to flow from one of the openings for several days after the first shock.

It is important to observe that in no case was it found that the water thus issuing from the earth was hot or noticeably above the temperature of water in shallow wells in the neighbourhood. Reports of boiling water having been thrown up were very numerous, but no evidence that the water was really hot appeared. The use of the word "boiling" doubtless grew out of the appearance of the water as it issued from the openings, and was probably used by eye-witnesses to describe this appearance with no reference whatever to temperature.

There were also reports of the appearance of blue flames in the neighbourhood of these eruptions, but no reliable testimony to their existence could be obtained. There was also a report that was circulated extensively through the medium of the press of the country that two or three showers of hot stones had fallen upon and near the office of the *Charleston News and Courier*. An examination of some of these shortly after they had fallen forced the conviction that the public was being made the victim of a practical joke.

In the city of Charleston about forty lives were lost. The greater number of casualties resulted from injuries sustained by persons who were either in the street at the time of the shock or who rushed out and were caught by the falling debris. No adequate description of the injury to property can be given in this place, and, indeed, the results of this earthquake have been so thoroughly considered in the public press that note is unnecessary.

While there was probably not a single house in the city which was not in some degree affected by the shock of August 31, there was naturally great diversity as to the extent of the damage in different localities. Some parts of the city are built upon what is called "made land," resulting in many cases from the filling up of old creek bottoms and from other extensive levelling and grading. A more careful study of these peculiarities and their distribution may lead to the discovery of some relation between local differences in structure and the areas of greatest destruction.

Unquestionably much is to be attributed to the difference in the character of the buildings themselves, and to the relation of their lines of greatest or least strength to the direction of the wave front. As was to be expected, buildings constructed of wood suffered much less than those of brick. The interior of wooden buildings, however, would often exhibit a scene of total destruction, furniture, book-cases, &c., having evidently been moved with great violence. A very brief examination of injured buildings sufficed to establish, in a general way, the principal direction of the movement, which was probably in a north-west and south-east line.

The probability of the destruction of a building depends so largely on conditions other than the amplitude or direction of the vibration of the earth particle that the study of destroyed or damaged structures can yield little exact information concerning these elements. The displacement of bodies of simple form and structure, lying near to or upon the surface of the earth itself, is a vastly more reliable index of the direction and intensity of the disturbance. In the churchyards of Charleston many instances of displacement and overturned monuments, columns, urns, &c., were found. These were examined with some care, and a careful study of the results may bring out some information concerning the dynamics of the earthquake. A cemetery containing many pyramidal or cylindrical shafts resting upon flat stone bases is tolerably certain, when disturbed by an earthquake, to exhibit not only displacement but also instances of twisting about a vertical axis; cases of this kind were numerous at Charleston. Such rotations by no means imply a similar gyratory motion of the earth, as it is well known that they may result, and doubtless always do, from vibratory motions in a single plane. It was not at all uncommon to find two columns, very near to each other, twisted in opposite directions.

A table was given containing a *résumé* of information received at the office of the Chief Signal Officer from regular observers of the Service and from a number of voluntary observers. The place, time, supposed direction, duration, and estimated intensity were given. Much discrepancy is observable in the records of time. Confusion is especially great in a few portions of the country in which so-called "local time" is still adhered to. Whenever "standard time" is known to have been used reduction has been made to that of the 75th meridian. In a few cases, however, no reasonable supposition can explain the discrepancies. Such records must be erroneous.

A study of this column will show the great importance, in making such observations, of determining the error of the clock or watch at the earliest possible moment by comparison with the time of some known meridian. It must be said, however, that the extended use of standard time has rendered these results vastly more accurate than they otherwise would have been. Telegraphic time-signals are now within the reach of most people, and during the past two or three years a great improvement in the accuracy of time-keeping among the people has taken place.

The direction of the movement recorded against each station is that given by the observer. As it is based in many instances on the motions of swinging objects, or easily movable objects, it is of necessity often erroneous. In the absence of correct instrumental records, however, such observations are of value. The numbers expressing the intensity of the disturbance were applied at this office, from descriptions furnished by observers, according to a scale adopted by the Director of the Geological Survey.

This scale is as follows:—

No. 1. Very light. Noticed by a few persons; not generally felt.

No. 2. Light. Felt by the majority of persons; rattling windows and crockery.

No. 3. Moderate. Sufficient to set suspended objects, chandeliers, &c., swinging, or to overthrow light objects.

No. 4. Strong. Sufficient to crack the plaster in houses, or to throw down some bricks from chimneys.

No. 5. Severe. Overthrowing chimneys and injuring the walls of houses.

With these intensity numbers an attempt has been made to plot a chart of iso-seismal lines, or lines of equal intensity. The result is shown in the chart. Nothing short of the use of well-constructed seismographs can furnish satisfactory measures of the amplitude of vibrations of the earth particle or the maximum velocity of the same, but in the absence of records of such instruments, this chart, or a more perfect one constructed upon the same plan, will afford opportunity for study.

In conclusion, it ought to be stated that this brief review of the Charleston earthquake must be regarded only as an attempt to place some of the leading facts upon record, for the benefit of the readers of the *Monthly Weather Review*. It is in no way intended to anticipate the investigations now in progress by the United States Geological Survey, a full report from which, based upon all attainable information, will be looked for with great interest.

THE SIMILARITIES IN THE PHYSICAL GEOGRAPHY OF THE GREAT OCEANS[1]

At the outset Mr. Buchanan reminded the audience of the similarities observed in the eastern and western continents, especially in their southern extremities. Such similarities in corresponding localities had been called homologous geographical features, in imitation of the homologies of comparative anatomy, and they had received much attention from students of geography. A remarkable group of similarities of this kind is to be found in the arrangement of inclosed seas lying to the northward of the three southern continents. To the northward of South America there are the Gulf of Mexico and the different basins of the Caribbean Sea; to the northward of Africa there are the Mediterranean with its different basins, and on the north-east the Red Sea; and to the northward of Australia there are the well-known seas of the Eastern Archipelago. These seas are bounded on all sides by islands and insular groups, and they are in continuous connection with two oceans, the Pacific and the Indian. The African seas are bounded entirely by continental land and communicate directly with two oceans; but in the limited sense that one sea, the Red Sea, communicates with the Indian Ocean by a single channel, and the Mediterranean Sea with the Atlantic, likewise by a single channel. Finally, the American seas are all in continuous communication with only one ocean, the Atlantic, the continental barrier towards the Pacific being continuous.

It is not unworthy of remark that the great depths (over 4000 fathoms) of the Atlantic and the Pacific Oceans occur immediately to the northward of these groups of seas, and in the western sinus of the northern portions of both oceans; while the greatest depression of the continental land, the region of the Dead Sea, is found similarly situated with regard to Africa. The analogy here, however, does not hold good all through, because it is a mere accident of climate that this area does not form a large and not excessively deep fresh-water lake.

The seas of the Malay Archipelago and those of the West Indies have important functions in the physical geography of the oceans, as they receive the warm dense water of the westerly-running equatorial currents of the Pacific and the Atlantic Oceans. The Pacific current finds no obstacle in the chains of islands which bound the Malayan seas, and is able to pass freely through into the Indian Ocean; while the Atlantic current is stopped by the continuous continental barrier of South America, and the head of water thus produced is relieved by the overflow of the Gulf Stream all the year round. Although there is no static barrier, in the shape of continuous land, to the westerly Pacific current, there is, during one season of the year, a kinetic one, furnished by the prevalence of the south-west winds during the monsoon season. These furnish the intermittent *kuro siwo*. The main cause of the westerly equatorial current is the propulsive action of the trade winds.

These winds have also great evaporating power; and, by making the surface water salter, they furnish the mechanical means of propagating the surface heat into the deeper layers of the ocean. Hence the leading characteristic of the westward or leeward regions of the intertropical oceans is water of considerable density and of high average temperature in the sub-surface layers. This characteristic is seen most clearly in the Atlantic, where there is no communication with another ocean. In the Pacific the non-continuous boundary neutralises to some extent this effect, and gives to the eastern parts of the Indian Ocean a borrowed leeward character, independent of its own climate. A secondary consequence of a leeward position in the ocean, and due to the above-mentioned characteristics of the temperature and density of such water, is the prevalence of coral formations in the western regions of the Atlantic and Pacific, and, owing to the mixture of conditions, in both eastern and western regions of the Indian Ocean.

Continental homologies, or similar features in corresponding localities, are found on the western as well as on the eastern sides of the continents. One of the most striking is the resemblance of the Gulf of Guinea on the African coast with the great Central American bight stretching from Cape St. Lucas at the extremity of the Californian Peninsula, by Panama, to the mouth of the Guayaquil River, and with the unnamed bight in the Indian ocean bounded continentally by the north-west coast of Australia and insularly by the chain of islands stretching from the Peninsula of Malacca to Australia. Oceanically these bights are homologous. It is in them that the beginnings of the westerly-running equatorial currents are to be found, and perhaps more important still, it is in them that the easterly-running counter equatorial currents end. They are to be found in each of the three oceans, and generally on the northward side of the axis of the westerly-running current. In the Atlantic it is best known by its eastern portion, the Guinea current.

The observations here recorded of the Guinea current, a hitherto unexplored region of the ocean, were made on board the steamship *Buccaneer*, at the invitation of the owners, the India-rubber, Gutta-percha, and Telegraph Works Company, of Silvertown, and were carried out during a survey for a telegraph cable from Sierra Leone to St. Paul de Loanda. From a diagram showing the variation of salinity of the surface water of the Guinea current, with distance from the coast, it appeared that for a considerable distance along the Guinea coast the salinity of the surface water was an almost accurate test of the proximity of the land. The Guinea current starts in mid-ocean, but it is most constant near the African coast. The density of the water is low, its temperature high, and its velocity, especially in-shore, is sometimes as great as three miles an hour. It varies somewhat with the season.

Bottle experiments showed an average rate of fifteen miles per day in the months of January and February, for a thousand miles along the coast. In March, the *Buccaneer* experienced no easterly current, and in connection with this absence of easterly currents off the coast may be taken the very remarkable under-current which is found setting in a south-easterly direction with a velocity of over a mile per hour at three stations almost on the equator, and to the northward of the Island of Ascension. For the double purpose of examining the currents and of obtaining a large specimen of the bottom, the *Buccaneer* was anchored in 1800 fathoms of water by means of an ordinary light anchor fitted with a canvas bag to receive the mud which would otherwise fall off the flukes on its being weighed. While the ship was lying thus at anchor, the surface water was found to have a very slight westerly set. At a depth of 15 fathoms there was a difference, and at 30 fathoms the water was running so strongly to the south-east, that it was impossible to make observations of temperature, as the lines, heavily loaded, drifted straight out, and could not be sunk by any weight the strain of which they could bear. In the Pacific the counter equatorial current in the open ocean was well observed by the

[1] Abstract, by the Author, of a Paper read at the meeting of the Royal Geographical Society on Monday, November 8, by Mr. J. Y. Buchanan.

Challenger on her voyage from Hawaii to Tahiti. Her observations were illustrated by two diagrams, one showing the direction of the current, and the other the distribution of temperature and density in the upper layers of the water traversed. The easterly current was found between the parallels of 5° N. and 10° N., there being two streaks of maximum velocity, one between 7° and 8° N., and the other between 9° and 10°. In the former the mean daily set was 54 miles; in the latter it was probably quite as high, but it could not be accurately determined, as the ship passed from westerly to easterly current in the course of the 24 hours, and the observed current of 20 miles represented the difference of the two. The streaks or axes of strong easterly current are sharply defined by areas of abnormally low surface density. The whole of the area of easterly-running water has a comparatively low density, but where there is a sudden acceleration of its velocity, there is a correspondingly sudden drop in its density, so that the existence of a strong easterly current in equatorial regions may be guessed with great probability by the use of the hydrometer. The diagram showed also in a very marked way the protective action of the fresh surface water in preventing the penetration of heat into the lower layers of the water. A temperature of 60° Fahrenheit is found here at a depth of 50 fathoms from the surface, while in the westerly-running current, a little further south, the same temperature occurs at a depth of over 100 fathoms. In this region there are great inequalities in the density of layers of water at the same depth and within a short distance of each other. Thus, if the column of water between 20 fathoms and 70 fathoms from the surface be considered, its weight at the station where the westerly-running equatorial current prevails is only 88 per cent. of its weight under the counter equatorial current, the distance between them being not more than 200 miles. This disturbance of statical equilibrium must be balanced by circulation of water between the localities, and hence the violent and conflicting currents observed in these regions. The study of the currents of equatorial regions would well repay the trouble of the investigation. The counter equatorial current is particularly interesting, and its dynamics obscure. Its range is very superficial, and its physical conditions can be studied without the elaborate and costly equipment required for the research of oceanic depths.

To the north and to the south of the equatorial bights of the western shores of Africa and America we have a remarkable similarity in the distribution of temperature in the coast waters. The transition from equatorial heat to extratropical cold is very marked: on the North American shore, at Cape St. Lucas, the southern extremity of the Californian peninsula; on the North African, at Cape Verd; on the South American shore, at Cape Blanco; and on the South African, at Cape Frio. In rounding Cape St. Lucas the temperature was observed to fall from 75° to 65° F. in less than an hour; and a similar difference of temperature was found in rounding Cape Blanco between Payta and the Guayaquil river. On the Morocco coast the water is found to have a temperature quite 10° lower than is found twenty miles to sea. These sharp transitions are found only close inshore, and they have usually been attributed to surface currents from higher latitudes. This explanation is at variance with the observations of navigators on the coasts, who do not notice any currents which would be strong enough to bring water many hundreds of miles under a burning sun without sensible rise in temperature. The occurrence of these coast areas of abnormally cold water is explained when we recognise that they are the windward shores of the oceans. The trade winds blow from them towards the equator, and in doing so mechanically remove water, which has to be supplied from the readiest source. This source is the deep water lying off the continental coasts, which is supplied by a gradual drift of cold water from high latitudes. Hence, though the low temperature of the coast waters referred to is due to the cold of high latitudes, it is not supplied by a long coast Polar current, but by a short vertical one. This view was very strongly supported not only by the temperature of the water, but by its other characteristics, especially colour. The outside ocean water is of an intense ultramarine blue; the coast water off Mogador had the clear olive-green colour met with constantly in Antarctic seas. The same is observed on the west coast of North and South America, and it would be of the highest interest to have these waters investigated from a biological point of view. No waters in the ocean so teem with life as those on the west coast of South America. A bucket of water collected over the side is turbid with living organisms, the food of countless shoals of fish, who, in their turn, afford prey for innumerable schools of porpoises. One remarkable school which accompanied the ship for some time consisted entirely of females, each accompanied by a calf following in her wake and mimicking her every movement. Along with abundance of life this coast unites facilities for investigating it. At every port there are plenty of shore boats anxious for a fare, and with a tow-net and a few bottles a naturalist might make a rich collection of the shore-water fauna of the coast in one trip from Valparaiso to Panama.

The most remarkable confirmation of the view that the cold water on the windward shores is due to a submarine source has been quite recently supplied by the observations of Capt. Hoffmann, of the German man-of-war *Möwe*, on a voyage from Zanzibar to Aden. He kept close to the coast as far as possible, and observed a very uniform surface temperature of 78° to 80° F. from Zanzibar to Cape Warschek, when it began to fall, and remained at a temperature of from 60° to 65° F., until Cape Guardafui was reached, when the temperature went up rapidly to 86°. The minimum temperature observed was 59° F., and Capt. Hoffmann calls particular attention to the dark-green colour of the water, and in speaking of its low temperature he recognises that its source can only be the deep water in the neighbourhood, as the surface water on both sides has a temperature bordering on 80° F. The *Möwe* passed through these seas in the month of July, when the south-west monsoon is blowing most strongly, and at this season the Somali coast is a pronounced windward shore, and exhibits the same characteristics as the windward shores of Morocco or South America. The coral growths, too, which are so abundant north and south of it are here quite absent, thus accentuating the eastern or windward character of the shore.

NOTES

THE following is the list of selected names to be submitted to the Fellows of the Royal Society at the forthcoming anniversary meeting (November 30) for election into the Council for the ensuing session:—President: Prof. George Gabriel Stokes, M.A., D.C.L., LL.D.; Treasurer: John Evans, D.C.L., LL.D.; Secretaries: Prof. Michael Foster, M.A., M.D., Lord Rayleigh, M.A., D.C.L.; Foreign Secretary: Prof. Alexander William Williamson, LL.D.; other Members of the Council: Prof. Robert B. Clifton, M.A., Prof. George Howard Darwin, M.A., LL.D., W. T. Thiselton Dyer, M.A., Prof. David Ferrier, M.A., Edward Frankland, D.C.L., Arthur Gamgee, M.D., Archibald Geikie, LL.D., Prof. Joseph Henry Gilbert, M.A., John Hopkinson, M.A., D.Sc., J. Norman Lockyer, F.R.A.S., Sir Lyon Playfair, K.C.B., LL.D., Prof. Bartholomew Price, M.A., Prof. Pritchard, M.A., Admiral Sir George Henry Richards, K.C.B., Prof. Arthur Schuster, Ph.D., Philip Lutley Sclater, M.A., Ph.D.

IN the third volume of Ray's "Historia Plantarum" there is a list of plants collected in the Island of Luzon by George Joseph

Camelli. This botanist was a member of the Society of Jesus, and was born at Brunn, in Moravia, April 21, 1661; after a life spent for the most part in the Philippines, he died at Manila, May 2, 1706. Linnæus commemorated him in the genus Camellia, and the introduction of this well-known plant into Europe is generally attributed to him. The manuscript transmitted by Camelli to Ray was accompanied by a large number of drawings, part only of which Ray seems to have been able to afford the expense of publishing. We learn from the *Comptes rendus* of the Société Royale de Botanique de Belgique for October 9, 1886, that the whole of the drawings still exist in a folio volume in good preservation in the library of the Jesuits' College at Louvain. It contains 257 autograph plates, with 556 figures of plants, and three plates, with nine figures relating to zoology. It was purchased at the sale of the library of Antoine Laurent de Jussieu (February 6, 1858), in whose handwriting it is carefully annotated, and was presented to the Jesuit College by Count Alfred de Limminghe.

DR. WALTER L. BULLER, C.M.G., F.R.S., the well-known New Zealand ornithologist, has been promoted to the Knighthood of the Order of St. Michael and St. George.

THE honorary degree of D.Sc. has been conferred by the Senate of the Royal University of Ireland upon the Rev. S. J. Perry, F.R.S., and Prof. John Perry, F.R.S.

THE Committee appointed by the Prince of Wales to assist in framing a scheme for the proposed Imperial Institute is ludicrously inadequate and unrepresentative. The President of the Royal Academy appears, but why is the President of the Royal Society omitted? Surely science will have far more to do with such an institute than art. The only representative of science is Sir Lyon Playfair, and he has been appointed probably more on account of his connection with the 1851 Exhibition than with science. If the Committee is to gain the confidence of the public it must be of a very different character.

IN view of the progress achieved of late in the domain of celestial photography, the French Academy of Sciences has decided to propose that an International Conference be held in Paris next spring to make arrangements for the elaboration of a photographic map of the heavens to be simultaneously executed by ten or twelve observatories scattered over the whole surface of the globe.

ACCORDING to the Report of the Director of the Leander McCormick Observatory of the University of Virginia for the year ending June 1, 1886, the buildings and instruments are in excellent repair; the great 45-feet dome revolving fully as easily as when first erected. The Parkinson and Frodsham clock, formerly belonging to the Physical Laboratory, has become the property of the Observatory. It is now in Washington, in the hands of a jeweller, to be cleaned and recased. The great equatorial has been chiefly employed in the examination and sketching of southern nebulæ. The nebula in Orion and the Trifid and Omega nebulæ have received special attention. 351 observations of miscellaneous nebulæ have been made, resulting in 226 drawings, and the discovery of 233 nebulæ which are supposed not to have been hitherto detected. The features seen indicate that the performance of the instrument employed surpasses that of any of the great reflectors which have been used in the examination of nebulæ, the examination of complicated structures seldom failing to show features not noticed elsewhere. Only a few nights have been suited to the micrometrical measurement of double stars. Seventy-six observations have, however, been made of stellar pairs, nearly all of which are close and difficult. According to the Director, Mr. Ormond Stone, the past year has been, without exception, the poorest for astronomical observations which he has ever known. Not only have there been an unusual number of cloudy nights, but even on clear nights the definition has been almost always extremely poor. The Observatory is open to the general public every day, except holidays and Sundays, between 2 and 5 p.m. It is also open to a limited number of visitors once each month at 8 p.m.

BY the kindness of the under-mentioned gentlemen, lectures will be delivered as follows before Christmas at the Royal Victoria Hall and Coffee Tavern:—November 16, Mr. A. T. Arundel (Madras Civil Service), "Glimpses of India and its People"; November 23, Mr. Arthur Brown, "The Yellowstone Region"; November 30, Prof. A. W. Rücker, "Early History of the Earth and Moon"; December 7, Rev. W. H. Dallinger, "Plants that Prey on Animals and Animals that Fertilise Plants"; December 14, Prof. Boyd Dawkins, "Introduction of the Arts into Britain." With regard to the classes now held in the building, about eighty students have joined, many of whom are attending more than one class, and it is expected that fresh classes will shortly be started. A very satisfactory feature of the matter is that the students are genuine artisans, who would not otherwise have good teaching within their reach.

IN the form of a leaflet reprinted from *Humboldt* (Band v. Heft 10), M. Habenicht, of Gotha, sends us a "Contribution to the Morphology of the Kosmos." Although his emendation of the nebular hypothesis can scarcely be called an improvement upon it, it is one among many symptoms of the breaking up of ideas on the subject, and their tendency to flow into new channels. M. Habenicht remarks that, in the primitive nebula, "the laws of Nature slumber." For the convenience of the majority of speculators on origins, their awakening should be indefinitely postponed. His theory of planetary formation depends upon disparity of temperature, the inner side of the originating ring being warmed by the central body, while the outer side radiates freely into space. The result is unequal contraction occasioning rupture at the weakest place, whereupon a remarkable process ensues. Through the *tightening* of its outer surface, the ring coils up from the outside into two spirals containing very different quantities of matter, which eventually rush together from opposite directions, and coalesce into a planet. This dual origin is visible in the dissimilarity of the terrestrial hemispheres, as well as in certain aspects of Mars, and in some rare glimpses by Dawes of the disposition of light and shade on Jupiter's third satellite. The analogy is even carried out, we are told, in the organic world, from the tiny seed-leaves of the embryo-plant to the symmetrical yet not strictly balanced arrangement of limbs in the highest order of beings. But the planet-producing rings, to behave as M. Habenicht supposes them to have behaved, should have possessed rather the qualities of caoutchouc than those of any known or imaginable "nebulous" stuff.

UNDER the title of "Sea-Level and Ocean-Currents," Prof. J. S. Newberry sends the following letter to *Science*:—"Put-in Bay Island, October 16, 1886.—At 11 o'clock Thursday evening, the 14th inst., I witnessed here a remarkable fact, the effect of the late tremendous wind-storm. This commenced about 7 a.m., and began to let up at 11 o'clock in the evening, or a little later. I then went down to the shore in front of my house, and found the lake lower than the average by fully 6 feet! This is the greatest depression from such cause I have noticed during a residence here of nearly twenty-four years. We have not, within this period, had such a high wind steadily continued for so long a time. The captain of the steamer *Chief Justice Waite*, running between Toledo and the islands, reports the fall of water-level at Toledo as about 8 feet." In discussing the general question with reference to previous correspondence, Prof. Newberry says:—"The question is, not whether the

wind has the power of raising the water-level on a coast, but whether wind-friction can, in the great equatorial belt and in the track of the Gulf Stream, produce the flow of water which is there observed. The striking cases of the power of wind to heap water on coasts, and to move bodily great masses of it in lakes, are only interesting and relevant as demonstrating the sufficiency of wind-friction to produce broad and rapid surface-currents. This conceded, and the case is won, because, in the lakes and open ocean, like causes produce like effects. Wind of given velocity raises in both places waves of equal height in equal times: against these waves the wind presses in the direction of its flow, with no opposing force. As a consequence, the roughened water-surface, from greatly increased friction, is moved bodily forward just as though impelled by the paddles of a revolving-wheel. This surface-flow is in time communicated to underlying strata, and, if the wind continue to blow in the same direction, ultimately a large body of water will be set in motion; in other words, an ocean-current will be produced. There is no escape from this conclusion. The great truth remains that wind-friction can produce ocean-currents."

A SHOCK of earthquake of a more or less severe nature was felt at noon on November 5 at Washington, Richmond, Wilmington, Raleigh, Augusta, Charleston, Savannah, Macon, and other places in North and South Carolina. At some points the seismic disturbance was the severest since August 31. A shock of earthquake was also felt at Greenville, Alabama, on Friday last. The captain of a vessel which has since arrived at Charleston reports having experienced a seismic disturbance on that day while at sea.

PROF. JOHN MILNE, of Tokio, Japan, writes with reference to Prof. Ewing's article on seismographs in NATURE, vol. xxxiv. p. 343, that the instruments therein described represent the state of general knowledge of the Seismological Society of Japan with regard to seismometry at the time of Prof. Ewing's departure from that country. With the exception of one or two which have been modified, a set of instruments like those recommended by Prof. Ewing are, so far as Japan is concerned, quite obsolete. A very much better form of instrument is Prof. Milne states, now in use in the Government observatories and throughout the country.

IN a paper by the Hon. Ralph Abercromby, reprinted from the *Quarterly Journal* of the Meteorological Society, on the origin and course of the squall which capsized H.M.S. *Eurydice* on March 24, 1878, the author concludes as follows:—"The squall which capsized H.M.S. *Eurydice* was one belonging to the class which is associated with the trough of V-shaped depressions. The line of this trough was curved like a scimitar, the convexity facing the front. The whole revolved round a point near the Scaw, in Denmark, like the spoke of a wheel. For this reason the portion of the squall over the east of England moved only at the rate of 13 miles an hour, while the western portion travelled nearly 50 miles in an hour. The portion which struck the *Eurydice* was advancing at the rate of 38 miles an hour. The length of the squall over England was more than 400 miles, but only 1 to 3 miles in breadth. Hence we have the picture of a scimitar-shaped line of squalls, 400 miles long and about 2 miles broad, sweeping across Great Britain at a rate varying from 13 to 50 miles an hour. The V-depression was one of an uncommon class, in which the rain occurs after the passage of the trough, and not in front of it, as is usually the case. The weather generally for the day in question was unusually complex, and of exceptional intensity, and for this reason some of the details of the changes cannot be explained."

AT a recent meeting of the Niederrheinische Gesellschaft für Natur- und Heilkunde at Bonn, Dr. Gurlt described a fossil meteorite found in a block of Tertiary coal, and now in the Salzburg Museum. He said it belonged to the group of meteoric irons, and was taken from a block of coal about to be used in a manufactory in Lower Austria. It was examined by various specialists, who assigned different origins to it. Some believed it to be a meteorite; others, an artificial production; others, again, thought it was a meteorite modified by the hand of man. Dr. Gurlt, however, came to the conclusion, after a careful examination, that there is no ground for believing in the intervention of any human agency. In form, the mass is almost a cube, two opposite faces being rounded, and the four others being made smaller by these roundings. A deep incision runs all round the cube. The faces and the incision bear such characteristic traces of meteoric iron as to exclude the notion of the mass being the work of man. The iron is covered with a thin layer of oxide; it is 67 mm. high, 67 mm. broad, and 47 mm. at the thickest part. It weighs 785 grammes, and its specific gravity is 7·75; it is as hard as steel, and it contains, as is generally the case, besides carbon, a small quantity of nickel. A quantitative analysis has not yet been made. This meteorite resembles the celebrated meteoric masses of Saint Catherine in Brazil and Braunau in Bohemia, discovered in 1847, but it is much older, and belongs to the Tertiary epoch.

DR. DOBERCK, the Government Astronomer in Hong Kong, has published a pamphlet entitled "The Law of Storms in the Eastern Seas," containing the practical results of investigations of about forty typhoons, continued during three years. He divides typhoons into four classes, according to the paths which they usually follow:—(1) Those which cross the China Sea and travel either in a west-north-westerly direction from the neighbourhood of Luzon towards Tonquin, passing south of, or crossing the Island of Hainan; or, if pressure is high over Annam, they travel first westward and then south-westward. These, which occur at the beginning and end of the typhoon season, can generally be followed for five or six days. (2) The second class are most frequently encountered, and their paths can be traced farthest. They generally travel north-westward while in the neighbourhood of Luzon, and either strike the coast of China south of the Formosa Channel, in which case they abruptly lose the character of a tropical hurricane, re-curve in the interior of China, and re-enter the sea to the north of Shanghai, pass across or near Corea, and are finally lost to the east-north-east. Typhoons of this class may pass up the Formosan channel, and re-curve towards the coasts of Japan, or they may strike the coast of China north of Formosa. A third of the typhoons belong to this class; they can be followed between five and twelve days, and are most common in August and September. (3) This class is probably the most numerous of all, although not so frequently encountered. Their path is along the east of Formosa, travelling northwards and passing near Japan. (4) Typhoons of this class pass south of Luzon, travelling westward. Their dimensions are very limited, and hitherto they have not been followed for more than a day or two. When a few hundred typhoons have been investigated, no doubt complete lists of the sub-classes of these four main classes will be obtained, and exceptional cases will be better understood. The pamphlet, which is largely written for the guidance of ship-masters and others, concludes with the remark that typhoons are of simpler construction, and their paths are more regular, than the storms of Europe. Typhoons are so violent near their centre that the whole disturbance is evidently ruled thereby; whereas storms in the North Atlantic and in Europe appear to be made up of a number of local eddies, some of which are by degrees detached from the chief disturbance and form subsidiary depressions. Dr. Doberck has not been able to ascertain the existence of a subsidiary depression in the China Seas during the last three years, and it is, therefore, doubtful whether they ever occur.

THE additions to the Zoological Society's Gardens during the past week include two Rhesus Monkeys (*Macacus rhesus* ♀ ♀) from India, presented respectively by Col. J. M. McNeile and Mrs. E. White; a Rose-crested Cockatoo (*Cacatua moluccensis*) from Moluccas, presented by Miss Townshend Wilson; twelve Barbary Turtle Doves (*Turtur risorius*) from Africa, presented by Mr. E. L. Armbrecht, F.Z.S.; four Copper-head Snakes (*Cenchris contortrix*), two Rattlesnakes (*Crotalus durissus*), a Hog-nosed Snake (*Heterodon platyrhinos*) from North America, presented by Mr. W. A. Conklin, C.M.Z.S.; a Long-nosed Snake (*Heterodon nasicus*) from Indiana, U.S.A., presented by Miss Catherine Hopley; a Fire-bellied Toad (*Bombinator igneus*) from Germany, presented by Mr. G. A. Boulenger, F.Z.S.; a Bactrian Camel (*Camelus bactrinus* ♂), bred in England, two Eleonora Falcons (*Falco eleonoræ*) from North Africa, a Macaque Monkey (*Macacus cynomolgus* ♂) from India, deposited; two Mantchurian Crossoptilons (*Crossoptilon mantchuricum* ♂ ♀), two Bar-tailed Pheasants *Phasianus reevesi* ♂ ♀) from Northern China, purchased; ten Barbary Turtle Doves (*Turtur risorius*), four Ring Doves (*Turtur communis*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN

STELLAR PHOTOGRAPHY AT HARVARD COLLEGE.—Prof. Pickering has recently presented to the American Academy of Arts and Sciences an important memoir on the work in stellar photography which has been carried on at Harvard College, mainly by aid of an appropriation from the Bache Fund. The memoir commences with a brief sketch of the history of stellar photography, from its origination in 1850, when Mr. J. A. Whipple succeeded in obtaining a satisfactory daguerreotype of Vega with the Harvard 15-inch equatorial, the first stellar photograph ever secured. In 1857, the collodion process having then been introduced, Prof. G. P. Bond resumed the investigation, and showed that photography was capable of doing real work in the observation of double stars. In 1882 some preliminary experiments with a lens of 2½ inches aperture were made, and with such satisfactory results that in 1885 the work was resumed with a Voigtländer lens of 8 inches aperture, and about 45 inches focal length, that focal length having been selected that the photographs might correspond in scale to the maps of the "Durchmusterung." Of the three departments into which stellar photography may be divided, viz. star-charting, photographing star-trails, and spectrum photography, Prof. Pickering has chiefly interested himself in the two latter. Star-trails—the images, that is, produced on a plate when the telescope is stationary, or is not following the star with precision—are made exceedingly useful. It furnishes the best method of determining the magnitudes of stars photographically, and the average deviation of the measures of the brightness of circumpolar stars on different plates proved to be less than a tenth of a magnitude, a greater accordance than is given by any photometric method. It is Prof. Pickering's intention to obtain determinations of the brightness of all stars north of 30° S. decl. by this method, and the work is now nearly completed. One of the plates taken on November 9, 1885, incidentally affords conclusive evidence that Mr. Gore's Nova Orionis was then much less bright than it was on the night of its discovery, some five weeks later. By photographing on the same plate circumpolar stars near their upper and lower culminations, the means for determining the atmospheric absorption on the nights of observation have been secured. Prof. Pickering has also made some experiments on the applicability of photography to the transit instrument, and concludes that the position of a star may be determined from its trail with an average deviation of only 0·03s. Prof. Pickering also shows how star-trails may be made useful in determining the errors of mounting of the photographic instrument. Photographs of stellar spectra have been obtained by simply placing a large prism in front of the object-glass. The spectra of all the stars over an extended area are thus obtained at a single exposure; an exposure of five minutes giving the spectra of all stars down to the sixth magnitude in a region 10° square. The entire sky north of 23° S. decl. is to be examined in this way, and the work is now far on the way to completion. An exposure of an hour shows the spectra of stars down to the ninth magnitude. A photograph of the Pleiades in this manner brings out the interesting fact that, with very few exceptions, all have spectra of the same class—a circumstance which seems strongly to confirm the idea of a community of origin. The exceptions may not improbably lie at a considerable distance on this side or the other of the group, and should, as Prof. Pickering suggests, receive attention in any study of the parallax of the Pleiades. Prof. Pickering also here discusses several theoretical points of interest, one being the relation between the dimensions of the lens employed and the light of the faintest star that can be photographed with it. He concludes, on the whole, that, where the telescope follows the star with exactness, the limiting amount of light may be assumed as proportional to the aperture divided by the square root of the focal length. Three photographic plates accompany the memoir: the first showing the photographic instrument, the second the trails of a number of close circumpolar stars, and the third several specimens of photographs of stellar spectra, those of Vega, Altair, and of the Pleiades being amongst the number.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 NOVEMBER 14-20

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on November 14

Sun rises, 7h. 18m.; souths, 11h. 44m. 35·5s.; sets, 16h. 11m.; decl. on meridian, 18° 18′ S.: Sidereal Time at Sunset, 19h. 46m.

Moon (at Last Quarter November 18) rises, 17h. 54m.*; souths, 1h. 43m.; sets, 9h. 37m.; decl. on meridian, 18° 13′ N.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	9 37	13 17	16 57	25 11 S.
Venus	6 49	11 27	16 5	16 16 S.
Mars	10 39	14 23	18 7	24 36 S.
Jupiter	4 35	9 57	15 19	8 15 S.
Saturn	20 2*	4 4	12 6	21 19 N.

* Indicates that the rising is that of the preceding evening.

Occultation of Star by the Moon (visible at Greenwich)

Nov.	Star	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image ° °
14	115 Tauri	6	4 2	5 11	139 295

Nov. 16 ... 13h. ... Saturn in conjunction with and 3° 3′ north of the Moon.

Variable Stars

Star	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·2	81 16 N.	Nov. 18,	3 8	*m*
R Arietis	2 9·6	24 31 N.	,, 18,		*m*
Algol	3 0·8	40 31 N.	,, 14,	0 45	*m*
			,, 16,	21 34	*m*
ζ Geminorum	6 57·4	20 44 N.	,, 18,	21 30	*m*
U Canis Minoris	7 35·2	8 39 N.	,, 18,		*M*
R Virginis	12 32·7	7 37 N.	,, 18,		*m*
S Ursæ Majoris	12 39·0	61 43 N.	,, 14,		*m*
U Virginis	12 45·3	6 10 N.	,, 18,		*M*
R Scuti	18 41·4	5 50 N.	,, 17,		*m*
β Lyræ	18 45·9	33 14 N.	,, 16,	0 0	*M*
η Aquilæ	19 46·7	0 43 N.	,, 16,	19 0	*M*
δ Cephei	22 24·9	57 50 N.	,, 14,	0 0	*m*

M signifies maximum; *m* minimum.

Meteor Showers

November 14 is the date of the *Leonid* shower, R.A. 149°, Decl. 22° N.

THE EROSION OF THE ENGLISH COASTS

THE opening meeting of the present session of the Geologists' Association took place last Friday evening at University College, when an address was delivered by Mr. W. Topley, President of the Association and Secretary of the British Association Committee on Coast Erosion. The subject of the address was "The Erosion of the Coasts of England and Wales."

Mr. Topley, in his address, referred to the great service

rendered to the country by Mr. J. B. Redman, who had given much attention to the question of coast erosion, and to whom the British Association Committee was greatly indebted. The speaker then proceeded, by the aid of diagrams and drawings on the blackboard, to describe the mode in which the sea acts on coasts of various kinds, and stated the rate at which erosion is taking place in different parts of the country. It was greatest along the coast of Holderness and Norfolk, where the sea gained on the land at the average rate of from 2 to 3 yards per year. But locally and during exceptional gales the rate was much higher. On January 30, 1877, parts of Norfolk lost an average of 3 yards for several miles, and near Bacton the loss was 15 yards. Typical instances of erosion were cited, among the places mentioned being Folkestone, Brighton, Worthing, Bournemouth, Westward Ho ! and Pembrokeshire. The speaker then went on to describe the shingle beaches and their changes, and to discuss the effects of natural and artificial groynes. On the south coast of England the shingle travelled from west to east, and if left to itself it would form a natural protection along the greater part of the coast, and the average amount of erosion would be small. But in certain places land-owners, town-councils, and other corporations desired that there should be no loss of land, and they erected groynes to collect the shingle, and so robbed the coast to the east of its natural protection. Worthing was heavily groyned and the shingle largely collected, but just east of the town the coast was rapidly receding. Folkestone pier was a large groyne which had collected an extensive area of shingle on its west side; Copt Point and Eastwear Bay, once protected by a continuous band of shingle, were now nearly bare, and the coast was rapidly going. At Copt Point land was laid out for building, and roads were made; but the notice-board advertising "this desirable freehold building land," was seen half-way down the cliff. Natural groynes were sometimes recklessly destroyed, and this was the case at Hengistbury Head, where ironstone was quarried from the cliff and foreshore; the reef had held back sufficient shingle to protect the land to the west, but when the reef was removed, the shingle travelled on, and the land rapidly receded. Great damage was done by taking shingle for road metal, ballast, or other purposes. The amount so taken appeared small and unimportant because a single storm might throw up as much as might be taken in many months, but the aggregate amount so removed was enormous, and must tell in time. It had been estimated that the shingle removed near Kilnsea in twenty years represented a bank 3 miles long, 31 yards wide, and 6 feet deep. It was interesting to note that the erosion of that part of the coast averaged only from three-quarters of a yard to a yard and a half per year for some time before the shingle trade was so largely developed; but later on, owing to the loss of the shingle, the rate of erosion rose from 3 to 6 yards per year. The change might not be entirely due to the cause mentioned, but it clearly was so to a large extent. Although the Board of Trade had now stopped the practice at that part of the coast, it was still in full action in a large number of places. The speaker then passed to the consideration of the land gained from the sea. A great part of the material worn from the coasts of Holderness and Norfolk was carried into the estuaries of the Humber and the Wash, and there formed banks of sand and silt of great hindrance to navigation, but when reclaimed of great agricultural value. Recent estimates showed that the area of land thus made in the Humber and Wash was far in excess of that lost. Taking the whole coast-line of England, it was probable that the total area of land was as great now as it was 500 years ago. Although the general result of a survey of this question was less serious than was generally supposed, it was evident that greater control was requisite over the action of land-owners and public bodies along the coast. The powers now vested in the Board of Trade might be more rigorously and systematically applied, or fresh powers obtained. This was especially desirable along the south coasts, as there the damage done by reckless groyning was enormous, but the area of land now gained was small.

OBSERVATIONS ON HEREDITY IN CATS WITH AN ABNORMAL NUMBER OF TOES

IN 1883 I contributed an article to NATURE (vol. xxix. p. 20) upon this subject, giving an account of my observations from 1879 up to the date at which the paper was written. The last observation was concerned with a family of four male tabby kittens, all of which possessed the abnormality to a very marked extent. This was the first family produced by a female tabby (and slight tortoiseshell) cat which, when born, was the most abnormal form which had come under my notice, possessing two extra toes on all the paws, *i.e.* seven on each fore-paw and six on each hind-paw. The right paws of this cat were figured in

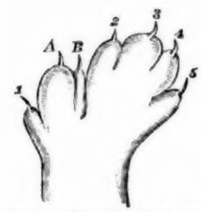

FIG. 1.—Right fore-paw from above, with extra toes.

FIG. 2.—Right fore-paw from below, with extra toes.

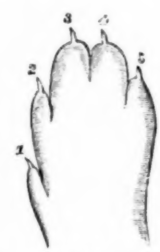

FIG. 3.—Right fore-paw from above, normal.

FIG. 4.—Right fore-paw from below, normal.

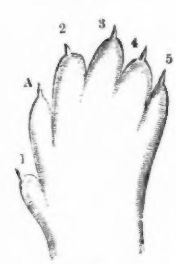

FIG. 5.—Right hind-paw from above with extra toes.

FIG. 6.—Right hind-paw from below, with extra toes.

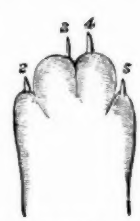

FIG. 7.—Right hind-paw from above, normal.

FIG. 8.—Right hind-paw from below, normal.

the paper referred to, together with the corresponding paws of a normal cat, for comparison. These figures are now reproduced in order to illustrate the present paper. I quote the description of the figures from the previous paper. "It is seen that the extra toes (in the fore-feet) are those labelled A and B (in Figs. 1 and 2), and they confer the extraordinary breadth upon the foot. The most recently added is B, which is still

partially coalesced with A, and has but one pad in common with it (Fig. 2). . . . There is seen to be an extra pad behind the additional toes, of which there is no trace in the normal foot." In some families to be described, and also in two previously noted, the large extra toe, A, is present, while the insignificant pollex (Fig. 1, 1) is absent, and thus the paw appears extremely broad, although with only the normal number of toes. In the hind-paws (Figs. 5 and 6) "there is little doubt that the innermost toe 1 is the hallux lost in the normal foot. . . . The second extra toe is that labelled A. . . . On the under side (Fig. 6) all the toes have separate pads, and there is an additional pad behind the extra toes," which is sometimes fused with that behind the normal toes.

This cat produced her first family, described in the previous paper, on July 10, 1883. Continuing the observations from that date, the next family (of four tabby kittens) was born in June 1884. (1) and (2) were normal—a male and a female. (3)—a female—possessed six toes on the fore-paws, each toe with a separate front pad, and a bifid hind pad (distinct from that for the other toes) to the two inner toes (1 and A in Figs. 1 and 2); the toe shown in the figure and absent in this kitten is of course that marked B—the last to be added in all cases. The hind-paws possessed six toes each, as in the mother, and with the same arrangement of pads as in her left hind-paw, *i.e.* with separate front pads to each toe (as in Fig. 6), but with the hind pads for the extra toes 1 and A continuous with those for the four normal toes (unlike Fig. 6 in this respect). (4), a female, possessed seven toes on the right fore-paw; the front pads separate except in the case of those for the toes A and B, Fig. 2, which were slightly fused. The hind pad for the three innermost toes was quite separate from that for the others. This paw, in fact, almost exactly resembled that of the mother-cat on the same side, shown in Figs. 1 and 2. The left fore-paw possessed six toes, the small one marked B in Figs. 1 and 2 being absent. The pads were in other respects similar to those of the right paw. Thus the relative amounts of abnormality on the two sides are as with the mother, the preponderance being on the right side in both cases. But the difference is here greater in both directions, the right paw having rather more abnormality than in the mother, because of the less complete fusion between the front pads of the toes A and B, while on the left side the abnormality is much less than in the mother, in the complete suppression of the toe B. The hind-paws were as in the last kitten, and similar to the left hind-paw of the mother.

The next family (of three) was born September 22, 1884. (1), a female tabby kitten, was normal. (2), a female tabby kitten, possessed seven toes on the right fore-paw, with separate front pads to each toe and the hind pad as in Fig. 2. The innermost claw was double, the two divisions being arranged vertically one above the other, the lower being small and incomplete. In this respect, and in the separate front pad to the toe B, this paw is far beyond the mother's paw of the same side in abnormality. The left fore-paw possessed six toes, that marked B being absent. Otherwise the arrangement of pads was similar to that shown in Fig. 2. Hence this paw is more normal than that of the mother on the same side, and both fore-paws compare with those of the mother in the same manner as those of No. 4 of the last family, the only difference being the even greater abnormality of the right paw in the present instance. The hind-paws possessed six toes with separate front pads and continuous hind pads, as in the left hind-paw of the mother. (3), also a female tabby kitten, possessed seven toes on both fore-paws. The arrangement of pads on both paws was similar to that on the left fore-paw of the mother, except that the toe B could not be said to possess a front pad at all. The hind-paws were as in the last kitten and the left hind-paw of the mother.

The next family (of three) was born in September 1885. (1), a female tabby and slight tortoiseshell kitten, possessed the normal number of five toes on the fore-paws, but the foot appeared almost as broad as in the abnormal kittens. This was because the large extra toe (A in Figs. 1 and 2) was present while the much smaller pollex 1 was absent. The front pad of the large abnormal toe was also slightly bifid, so that there was some indication of the next small toe B. The hind-paws possessed five toes with separate front pads and fused hind pads. (2), a female tortoiseshell and tabby kitten, possessed fore-paws like those of the kitten just described. The right hind-paw was also similar, with five toes, but the left possessed six like the mother. The front pads were separate, as usual, on the hind-paws. (3), a female tabby and slight tortoiseshell kitten, with fore-paws having seven toes like the mother, and also resembling her in the difference between right and left. The right paw possessed most abnormality, and was more advanced than the mother, as all the toes—even that marked B—possessed separate front pads. On the left side, however, the toe marked B possessed no separate pad. The hind-paws were like those of the mother, possessing six toes with separate front pads. This kitten was given to a friend, and will be again referred to.

The next and last family (of four kittens) up to the present time was born about July 1, 1886. (1), a female tabby kitten, was normal. (2), a female tabby kitten, possessed five toes on the fore-paws, but the feet were very broad, because the large abnormal toe (marked A, Figs. 1 and 2) was present instead of the small pollex. The hind-paws possessed six toes like those of the mother. (3), a male sandy kitten, possessed seven toes on the left fore-paw, the innermost (pollex) being *exceedingly* small and rudimentary, while the right paw possessed only six toes, the pollex being absent, although both abnormal toes (A and B, Figs. 1 and 2) were present. In this kitten the difference between the sides is therefore the reverse of that in the mother. The hind-paws possessed six toes like those of the mother. (4), a male tabby kitten,—by far the most abnormal form which has yet come under my personal notice. Both fore-paws have seven toes, each possessing a separate front pad, while the claw of the small toe B is well formed and large, and its pad is large and quite distinct and separate from that of A. The claw of the pollex 1 on both sides is partially divided (towards the apex) into a large upper, and rather smaller lower, division. This tendency towards a vertical proliferation has been already described in one of the kittens of the family born September 22, 1884. In the hind pads this was also the most abnormal form yet seen, for, interior to the normal fused hind pads for the four normal toes 2, 3, 4, and 5, were arranged three pads forming an almost continuous series with each other and with those belonging to the four normal toes. These three pads diminished in size from within outwards, and the one behind the toe B was very small, and was somewhat separated from the others, and especially associated with the internal side of the fused normal pads. The hind pads for the toes 1 and A were fused, but a distinct furrow indicated the line of separation. There was no practical difference between the fore-paws of the right and left side. The right hind-paw possessed *seven* toes, or three more than in the normal animal. This is the first time that I have come across so great an abnormality in the hind-paws, although Mr. Vaughan remembers it on both right and left sides in two individuals. All the seven toes are large and distinct, and have separate front pads. Interior to the normal fused hind pads, and continuous with them, is an ill-defined series of three pads, irregularly diminishing in size towards the interior, and crowded together so that the innermost is not behind the innermost toe. The foot is somewhat deformed. The left hind-paw possesses the usual six toes with separate front pads and fused hind pads.

I now return to (3) of the family mentioned before the last—the highly abnormal female tabby which was given to a friend in Oxford. This cat produced a family (of four) on July 10, 1886. (1) and (2), both sandy male kittens, were normal; (3) and (4), both tabby female kittens, were like the mother, possessing seven toes on the fore-paws and six toes on the hind-paws. These two kittens were given to Prof. Meldola and Mr. W. White, and I trust that they will be frequently referred to in some future number of NATURE. I am now able to give a somewhat longer account of these two kittens. In Prof. Meldola's kitten the left fore-paw is somewhat less abnormal than the right, because the toe B is very small, although it possesses a front pad separate from that of A. Of course the pollex 1 has a distinct front pad. There is a single, although somewhat divided, hind pad for the three inner toes, separate from the normal pad behind the four outer digits. On the right side the toe B is large, but the arrangement of front and hind pads is the same as that on the left side. The hind-paws have large and distinct front pads on all the six toes of both sides, and the hind pads of the abnormal toes form a continuous series with those behind the normal digits.

The fore-paws of Mr. White's kitten are precisely similar in every respect, the toe B being much larger on the right side, and the arrangement of pads being exactly the same. The hind-paws only differ in the fused hind pads for the abnormal toes being somewhat separated from those behind the normal

I. Tortoiseshell ♀ normal (Bristol)

II. Tortoiseshell ♀ normal (Bristol, and ? Haverfordwest)

III. Tortoiseshell ♀ abnormal, but notes not taken (? Bristol, and Haverfordwest)

IV. Tortoiseshell ♀ "Punch," 6 toes on all paws (Haverfordwest)

V. Tabby ♀ 6 toes on all feet (born 187) and sent to Reading)

Very many families, among which two kittens with 7 toes on all paws have occurred. All varieties between the extreme and normal form have occurred constantly. In old age all kittens are described as normal

VI. (1) 1880 (Reading)
Tabbies { i. ♂ FP 5 but abnormal, HP 5; ii. and iii. ♀ normal
iv. Tabby ♀ FP 5 but abnormal, HP 6 (Reading)

(2) 1881 (Reading)
Tabbies { i. and ii. ♂ ♀ normal; iii. ♀ 6 on all paws

(3) 1881 (Reading)
Colour unnoted { i. and ii. ♀ 6 on all paws; iii. sex unnoted, 6 on all paws

Many other families born in Reading, and always a large proportion of abnormality, but I was unable to obtain notes

VII. (1) 1881 (Reading)
Colour unnoted { i. and ii. ♂ ♀ normal; iii. ♀ FP 5 but abnormal, HP 6; iv. ♀ FP 5 but abnormal, HP 5

1882 (Reading, and sent to Oxford same year)
Tabby ♀ FP 7, HP 6 (sent to Oxford)
(Others in same family unnoted)

Many other families born in Reading, and always a large proportion of abnormality, but I was unable to obtain notes

VIII. (1) 1883 (Oxford)
Tabbies { i. ii. and iii. all ♂ and all FP 7, HP 6; iv. ♂ RFP 7, LFP 6, HP 6

(2) 1884 (Oxford)
Tabbies { i. and ii. ♂ ♀ normal; iii. ♀ FP 6, HP 6; iv. ♀ RFP 7, LFP 6, HP 6

(3) 1884 (Oxford)
Tabbies { i. ♀ normal; ii. ♀ RFP 7, LFP 6, HP 6; iii. ♀ FP 7, HP 6

(4) 1885 (Oxford)
Tabbies with some tortoiseshell { i. ♀ FP 5 but abnormal, HP 5; ii. ♀ FP 5 but abnormal, RHP 5, LFP 6
iii. Tabby ♀ (with slight tortoiseshell), FP 7, HP 6

(5) 1886 (Oxford)
Tabbies { i. ♀ normal; ii. ♀ FP 5 but abnormal, HP 6
Sandy iii. ♂ LFP 7, RFP 6, HP 6
Tabby iv. ♂ FP 7, RHP 7, LHP 6

IX. ... ...

(1) 1886 (Oxford)
Sandy i. and ii. ♂ normal
Tabbies iii. and iv. ♀ FP 7, HP 6

Capitals used for those female cats which have produced families of which some note has been taken

"I., II.," &c. = generations

"1, 2," &c. = families

"i., ii.," &c. = kittens in each family

Dates and localities indicate times and places of birth of the families to which they are affixed

"FP" = fore-paw { the numbers after = toes

"HP" = hind-paw { the letters R or L before = right or left side

"FP 5 but abnormal" indicates that the small pollex is absent, but the large abnormal toe A in Figs. 1 and 2 is in its place, making the paw abnormally broad, although with only the normal number of toes

digits on the left side, while the two sets are continuous on the right paw, as in Prof. Meldola's kitten.

All the observations recorded in this paper were made in Oxford. The abnormality has now been observed through nine generations, and I have recorded notes of ten families, so that now there is sufficient material to present in a tabular form.

The notes given in this paper are much more complete than before, because the families were born in my own house or in that of a friend living near, who kindly gave me every opportunity of making notes. The results, however, would have been far more extensive if I had received intelligence of the birth of families in various quarters to which kittens had been sent.

I believe there is little doubt that the next period of three years will produce much better results in this way, for at the recent meeting of the British Association at Birmingham I exhibited the cats, and was able to give away three abnormal females to scientific gentlemen (Prof. Haddon, Prof. Meldola, and Mr. W. White) who I am sure will assist me by sending complete accounts of all the families born. I remarked in my last paper on the immense strength of heredity which was shown in the observations then recorded, remembering that the results were in all cases due to the mothers of the families. The continued observations now published serve to illustrate the same facts. As I said before, "it is practically certain that the fathers of the families have always been normal." There has, indeed, been an abnormal male cat in Oxford for the last two years—one of my kittens which I gave to Prof. Moseley for a museum specimen, and which has been kept in order that it may be quite mature. But this cat lives at some distance from my house and that of the friend to whom I gave the female kitten in 1885, and it has never been seen in our neighbourhood, while numbers of normal cats have been seen in company with our abnormal females. But nevertheless a family containing abnormal kittens was born in a house near that in which Prof. Moseley's cat is being kept, and of which, of course, the latter must be the male parent. Unfortunately, as in so many other cases, I was unable to obtain any data, and the kittens are, I believe, all dead.

We therefore see in these observations a proof of the extraordinary ease with which a distinct breed can be produced from a spontaneously appearing variety. In spite of all the swamping effect of continual and uninterrupted crossing with the normal form, I have never been able to record a normal family, while in many cases some of the kittens were equal to, or even beyond, the abnormal parent in her peculiarity. This being the case, it is clear that a breed would have been quickly established if abnormal males had been selected to pair with the abnormal females. These observations have, therefore, an interesting bearing upon the existence of such a local breed as the tailless Manx cats, as Prof. E. Ray Lankester pointed out to me when talking over the subject. Prof. Lankester supposes that a tailless individual appeared spontaneously, and that it was considered interesting and a curiosity; and when the abnormality re-appeared in some of the off-pring, these were kept in preference to the normal forms. It seems quite certain that the result might have been produced in this way, and I have arranged with Dr. Grabham, of Madeira, that some of my abnormal kittens shall be sent to him to turn loose upon some neighbouring Atlantic rock on which rabbits are the only other living mammals. I should add that Prof. Lankester found a support for the theory of the origin of the Manx breed of cats in the fact that there are tailless breeds of other animals which are also fashionable in the locality, and which seem to point to the existence of the same peculiarities of taste working upon a spontaneous variety. In fact, as Prof. Lankester suggested, the people may have rather looked out for other tailless or abnormally short-tailed animals, when their interest had been excited by the existence of one such breed. But the observations here recorded have also a bearing upon those cases in which natural, instead of artificial, selection has been the agent. Granting, as I believe we must do, that some adaptive characters of great importance owe their beginning to flashes of structural or functional originality—appearing suddenly and spontaneously in one individual, as the extra digits appeared in the ancestor of my cats,—we see from these observations that in spite of all the effects of constant intercrossing with normal forms, there would be a most persistent offer of material upon which natural selection might work, for the variation would appear to a greater or less extent in a very large proportion of the individuals of the various families produced, while again and again the peculiarity would be inherited in a form equal to or even beyond that of the parent. It is therefore of interest to actually test a few instances in as complete a manner as possible, taking care that only one parent possesses the abnormality, for this is what must have happened for the first few generations of any such variety which originally appeared in a single individual in a natural state. It is chiefly with the object of adding another to the instances already known and worked out that these observations have been undertaken, and will be continued and rendered as complete as possible. It need scarcely be pointed out that such instances differ essentially from all the cases in which breeds of domestic animals have been established, for in these well-known and numerous breeds heredity has had undisturbed possession of the field, without any confliction between the normal and abnormal forms, except indeed in the case of the first family produced by the original parent of certain breeds of which the peculiarity appeared spontaneously in a single individual, as in the breed of "otter" sheep.

EDWARD B. POULTON

LIGHTHOUSE ILLUMINANTS[1]

THE details of the construction of the three towers and lanterns, and of the lenses and lamps in each lantern, of the magneto-electric machines, and of the gas-works, have no doubt been placed on record, and will be reported by the Trinity House engineers. But the following may serve as a general description of the arrangements.

Three low towers, constructed of massive timber, have been erected in a line inland from the higher of the two permanent lighthouses on the South Foreland, the nearest being 245 feet distant from the lighthouse, and the three being separated one from another by intervals of 180 feet. Their height, varying with the level of the ground, so that the lanterns may be on the same level, is from 20 to 30 feet; upon these structures rest three similar lanterns about 20 feet in height and 14 feet across. Within the lanterns are columns of lenses forming two opposite sides of a hexagonal framework which rises from the base to near the top of each lantern. The whole framework can be made to revolve so that either column of lenses may be made to face in any direction; each column consists of three or four similar lenses superposed, but the lenses forming different columns are different in their purpose and structure, and in their size. One column in each lantern consists of lenses designed to gather the divergent rays which fall upon them from the central source of light into a level sheet which spreads over the surface of sea or land, but not downwards or upwards; each of these lenses is a segment of a cylinder, and may be described as a cylindrical lens. The opposite column in the gas and oil lanterns consists of lenses designed to gather the divergent rays, not into a sheet, but into a single cluster or cone of small vertical angle, which is sent forth horizontally in any one direction. These lenses are made up of a central circular lens, surrounded by annular prisms and segments of such prisms, the whole fitting into a rectangular frame; they may be called annular lenses. The corresponding column of lenses used with the electric light consists of cylindrical lenses with condensing prisms placed in front of them; the cylindrical lens flattens a broad cone of light into a fan, the condensing prisms close the fan.

The size of the cylindrical lenses placed in front of the gas and oil lamps is the same, but the lenses in front of the superposed electric lights are smaller. The annular lenses, of which three form a column in the oil lantern, are each 6 feet 3 inches in height, while the four superposed annular lenses in the gas lantern are each 3 feet 9 inches in height. Both sets of annular lenses have the same width, namely, 3 feet 5 inches.

The electric lights are large arc lights, supplied with the electric current by three magneto-electric machines, which are worked by the steam-engine in the engine-house built for the ordinary work of the station. The electrical apparatus is of the construction of Baron de Méritens.

The gas-burners tried hitherto are of Mr. Wigham's construction, consisting each of a multitude of small fish-tail jets on brass stems about 6 inches long and an inch one from another, arranged on the same level in concentric rings. A tall funnel, a few inches above the cluster of burners, draws their flames together into the form of a bell. The number of concentric rings may be changed quickly so as to increase or reduce the size of

[1] Preliminary Report of Mr. Vernon Harcourt to the Board of Trade on the Experimental Lights exhibited at the South Foreland.

the burner from a diameter of about 4 inches with 28 jets, to a maximum of 11 inches diameter and 108 jets.

The oil lamps are of the usual Trinity House pattern with six concentric wicks, and are fed with paraffin oil.

Cannel gas is manufactured and stored at a short distance from the experimental towers, and supplied through a meter to the gas-burners.

For the observation of the lights, which were first shown in the week beginning March 30, three huts have been erected at different distances along a line perpendicular to the line of the towers, and this line has been marked by posts showing the distance from the central tower. The lighthouse-keepers who are stationed in one or other of these huts are instructed to make hourly observations during the time the lights are exhibited, expressing in figures their estimate of the relative brightness of the three lights. When the night is misty the keepers are instructed to patrol the line of posts, and to record the distance at which each light is lost or becomes visible. To avoid prejudice in favour of either an old or a new mode of lighting, the towers have been labelled, and are called A (electricity), B (gas), and C (oil). The huts are numbered. No. 1 is rather more than 700 yards distant from the central tower, No. 2, about 1½ mile, and No. 3, 2½ miles. Steps have also been taken to obtain estimates of the relative brightness of the three lights from observers at greater distances. To secure the identification in each hut of the lights observed when all three are not visible, three tubes have been fixed in each hut directed towards the lights A, B, and C, and labelled accordingly.

The huts serve also for measurements by various photometric methods of the light sent forth from each lantern. A number of such measurements have already been made, the results of which have been communicated to the Board of Trade by the Trinity House.

Near the engine-house on the South Foreland a long gallery has been built, in which the light emitted by the various lamps employed or proposed to be employed, can be measured so as to ascertain the value of these lamps independently of the lenses by which, within the lighthouse lanterns, their apparent brightness is variously augmented.

The experimental inquiry thus instituted will serve :—

(1) To ascertain the amount of light given by the six-wick and seven-wick oil-lamps, and of other oil-lamps, or modifications of them (if any) which may be proposed for lighthouse service.

(2) To ascertain similarly the amount of light given by Wigham's gas-burners on different scales (28, 48, 68, &c.) with different rates of consumption, and, if thought well, with different qualities of gas, and to test other gas-burners in like manner.

(3) To furnish further and trustworthy measurements of the light given by the electric arc with various carbons and with various tensions and quantities of electricity, and to test the efficiency of the De Méritens magneto-electric machines in converting mechanical into electrical energy, and whether they work without difficulty or risk of break-down or need of repair or loss of power; also to test the working of the De Méritens electric lamp, and of other electric lamps, if thought well.

(4) To furnish additional data for estimating the cost of maintaining any given light for a certain time, say 1000 candles for one hour, by each mode of producing light, and on the various scales suitable to different localities.

(5) To measure the efficiency of the lenses employed, especially with flames of different sizes in their foci.

(6) To prove experimentally (if such proof be desired) that 2 or 3 or *n* similar lights, when juxtaposed, give twice or thrice or *n* times as much light as a single light gives.

(7) To ascertain what light is sufficient to be visible from its horizon on a clear night, and in what ratio on the average of many nights the visibility of a light at great distances increases with its total intensity, or lens area, or proportion of red or of blue rays.

(8) To test the effect of the variations last named in haze, or mist, or fog, or rain, or snow, that is, when the air is made more or less opaque by particles of liquid or solid water of various sizes suspended in or falling through it. Such testing may be made either photometrically, which is only possible in slight haze and at small distances, or by observations of the distance at which each light is lost or reappears.

(9) To try the question of the utility of ex-focal light, whether, that is, it often happens that the position of a lighthouse may be seen by the illumination of cloud or fog above or around it, when its position would be unknown if equal light from a smaller focus were directed almost wholly towards the mariner, and not allowed to spread.

(10) To test further whether in mist or haze sudden flashes of a powerful beam of light are noticeable when an equal light maintained constantly, or waxing and waning gradually, would not be noticed.

It is likely that other subjects of experimental inquiry may be suggested by those experienced in lighthouse illumination, or may occur as the experiments proceed. But, taking those above enumerated in order, I will attempt to indicate the conclusions which at present appear probable, and to make some suggestions as to points still to be investigated.

(1) It appears that the six-wick oil lamp behind the annular lens sheds light of as great intensity as the seven-wick lamp, while its consumption of oil is much smaller. Probably this result is due, in part, to the fact that the outer ring of flame which the seventh wick adds is further from the focus of the lens, while each ring of flame is partially opaque to the light from the rings inside it; and partly to the fact that the seven-wick lamp has not yet been brought to so perfect an adjustment of oil-supply to air-supply as the six-wick lamp.

I do not know whether any oil-lamp used in other than English lighthouses is such as to merit a trial against the Trinity House lamp.

(2) Some observations have been made with Mr. Wigham's burners with 88 and with 108 jets, which seem to show that with gas as with oil, behind the annular lens, no gain in intensity of light results from the circaposition of another ring of flame. Some evenings should, I think, be devoted to trying this question out. The value of ex-focal light behind an annular lens seems to be almost *nil* as regards intensity, and, if so, it may be well to use with revolving light a smaller flame than that of the six-wick lamp. Excellent experiments on this question can be made with Mr. Wigham's burner by exhibiting on a clear night through the annular lens one of these burners, whose size should be reduced, after an interval sufficient for photometry, from 108 jets to 88, and so on to the smallest size, measuring also after each change the consumption of gas. It will probably be found that a large fraction of the *directed* light is still obtained with a relatively small consumption of gas, and with the accompanying advantage of a low temperature within the lantern.

Similar measurements should be made with a cylindrical lens and with the naked flame in the photometric shed.

At present one other gas-burner besides Mr. Wigham's has been tried, a ten-ring gas-burner devised by Sir J. Douglass, which has given an excellent yield of light. Two others, by W. Sugg and Co., and by the F. Siemens Company, await a trial. The problem which the maker has to solve is to pack as much highly luminous flame as possible into a sphere of 3 or 4 inches diameter.

Where gas has to be manufactured expressly for a lighthouse, it would generally be best to make cannel gas, but near a town where common gas could easily be laid on, it would be cheaper to use common gas. It might, therefore, be worth while during the course of the experiments to charge the small gas-holder with common gas, and to note the consumption and the light developed. It would probably be found that with suitable burners the chief disadvantage in using common gas was the greater development of heat, the same light being obtained from the consumption of a larger volume of lower priced gas.

(3) Many measurements have been made in recent years of the light of the electric arc, but the difficulty of making measurements of so variable a light, and the uncertainty attaching to the standards of light employed, and the great differences between one arc light and another, according to the electric current and the carbons employed, make it clearly desirable to have further measurements of the electric light at the South Foreland.

Photometry should be accompanied, as with oil and gas, by a measurement of consumption. The mechanical energy absorbed can be measured at the strap which connects the magneto-electric machine with the steam-engine. The electrical energy developed can be measured in tension maintained, and quantity used, at the leads connecting the machine with lantern A. The cost of each horse-power per hour on the actual scale of working at the South Foreland must be already known. The rate at which the two forms of carbons which have been tried are consumed is also known.

It is essential to the value and significance of the photometry that simultaneous electrical measurements should be made.

The possible variations in the coupling of the magneto-electric machines, in the rate of running, and in the nature, form, and adjustment of the carbons, present a wide field of experimenting.

The continuance of the experimental working for many months will serve for a trial of the trustworthiness of the De Mériten's apparatus for lighthouse service.

(4) The cost of maintaining a lighthouse supplied with gas has been very variously estimated. It must vary from place to place, especially with the price of coal. The actual working expenses of oil lighthouses on the English coast, and gas lighthouses on the Irish coast, with allowance for the price of coal and labour, should furnish trustworthy data for a comparison. But to complete these data the quantity of light produced and utilised in each case needs also to be known, and as both the oil and gas burners tried hitherto at the South Foreland are of the service kind, the photometry now in progress will supply this knowledge. Some information may also be gathered from the expenditure on each illuminant at the outset and during the course of the experiment. It should be possible to state, if it were desired to maintain on the South Foreland a light of 50 or 100 or 200 thousand candles, what its annual cost cost would be with each illuminant.

(5) Although the action of lenses is mainly calculable, and, so far, does not require trial, it is modified by two quantities which vary slightly, namely, the reflection and absorption of light by glass, and is affected to some extent by errors of workmanship. It will, therefore, be of interest to obtain an exact comparison between the light emitted by a naked flame, and that from the same flame concentrated by different types of lighthouse lens. The prediction of the effect of a lens is less possible when the illuminant is of large size; and the failure of lenses, constructed for use as a revolving light with gas, to utilise (except by broadening the beam) the light produced at a distance of more than two or three inches from the focus of the lens, if they are found to fail so far, may be worth demonstrating.

With the electric light a very close correspondence should be found between the calculated effect of the cylindrical lens and of the condensing prisms and the results of photometry.

(6) The measurements which have been made of multiform gas and oil may be taken to show that any number of lights at a given distance cause so many times the illumination which one light causes; or assuming that the above must be the case, and is involved in the conception of comparative illumination, the proportional variation of the photometric results with the changes from uniform to biform, &c., on clear nights, gives evidence of the trustworthiness of the photometric methods.

(7 and 8) The two questions, which I have numbered thus, can hardly be treated separately, since clearness differs only in degree from slight haze, and slight haze from fog. Together they constitute the chief object of this inquiry.

The observations of the experimental lights which have been made from a distance, may be expected to yield, when they are collected and compared, much information as to the distances at which the several lights have been seen in various weather. But the changes which are necessary when photometric testings are to be made, or when an extensive programme is to be exhibited, must to some extent have interfered with the observation of the changes due to variations in the transparency of the atmosphere. It might be well for at least one month, to show the same lights nightly, and to inform the distant observers that this was about to be done, in order that their observations might have the more value. A single light of each kind shown through the cylindrical lenses would serve as well as multiform lights, and it would be best to use that size of gas-burner which had through the lens equal illuminating power with the six-wick oil lamp. Unless, indeed, it is assumed, as I should be inclined to assume, that equal lights from gas and oil have the same power of penetrating haze; in which case it would be more instructive to show from tower A a single electric light supplied from one machine, and from B and C either gas or oil also single, and either oil or gas of such size and number as to have at close quarters on a clear night an illuminating power equal to that of the electric light. A sufficient series of distant observations of these lights would show (1) whether the electric light maintained its equality with the larger hydrocarbon flame through slight haze, or became more nearly equal to a flame of much less initial brightness; and (2) whether the taller beam of multiform oil or gas had much advantage over the beam sent forth from a single lens. I believe it will be found that the relative brightness of two, or more, to one, will be maintained at any distance and through any haze which permits of photometry, but that, when the single light is lost at 5 miles or 500 yards, the triple light will be invisible at 6. The actual figures corresponding to these conjectural figures must be found, and the Trinity House Committee will then be able to judge in what cases such an extension of range is worth the increased expenditure.

In the case of the electric light, the observations which have already been made show that it loses in haze a larger proportion than the hydrocarbon flames. Further observations on this point will be of much interest and importance. The most valuable are observations of the distances at which an electric and a gas or oil light, whose relation in clear weather is known, cease to be visible. Such observations are strictly photometric observations, in which the lights observed are brought to an equality of minimum appreciable brightness, and the distances at which their brightness is equal are measured. These are dependent upon the weather, and may be practicable on only a few days in each month. Still more rarely will the opportunity offer of measuring the lights in hut No. 1 through a slight uniform mist; but such measurements ought to be made. I would suggest the possibility of testing in the photometric shed through an artificial mist produced by blowing steam from the boiler in the adjoining engine-house into the middle of the shed.

It is said that Faraday proposed at first the use of a very small lens with the electric light. Unless conclusive experiments have been made on this point, it may be well to place the experimental electric light in the focus of a larger and of a smaller annular lens, each subtending the same angle, and to note whether the effect differs.

It might also be worth trying whether biform gas, with a small enough number of jets to have the same illuminating power as single oil, would be better seen through slight haze. The trial would not be between gas and oil, but between placing a strong light behind one lens, and placing half the light behind each of two superposed lenses.

(9) Owing to the nearness of the three lanterns, the illumination or halo which spreads round each of them in a fog seems almost to blend. That which surrounds the gas lantern is not much greater than that around its neighbours on either side. I do not think that, on the one occasion on which I have seen the lights in a fog, the ex-focal light was of much service.

If a lighthouse lantern was surrounded by a mist or cloud extending far enough laterally to extinguish its principal beam, but so little above it as to allow the scattered light to fall upon a higher stratum of cloud, the position of the lighthouse might only be seen from the illumination of the cloud above it. But this state of things would happen rarely in most places, and a better plan of turning it to account than the addition to a burner of rings of ex-focal flame would be to employ the upper prisms to send a second beam skyward. Whether the general illumination about the experimental lanterns has been visible when the three centres of light were not visible to an observer towards whom the beams were directed, may perhaps be gathered from the record of observations.

(10) When engaged on a clear night in judging of the experimental lights, the eye of the observer is continually caught by the sudden flashes of the Calais light. The revolving light at Grisnez is equally visible, but does not catch the eye in the same manner. It might be well to try on some rather hazy night, whether, if one lantern alone were lighted, and during successive quarters of an hour the light were alternately kept steady and flashed in some such groups of flashes as the Calais light, the observers patrolling the line of posts became aware of the light at a greater distance when it was flashed than when it was steady or revolving. Even a slight mist is a great leveller of distinctions, but it seems possible that the use of flashing may increase the range of a light as much as an addition to its intensity or size.

Some of the questions raised in the latter part of this report might perhaps have been omitted, as having already received an answer, if, while thinking the matter over, I had been able to consult some of the experienced members of the Trinity House Committee who are charged with the conduct of this inquiry. I have ventured here in writing, as at other times by word of mouth, to make the suggestions which have occurred to me, knowing that they will receive friendly attention if they are

submitted to the Committee, and hoping that some of them may be of service. (Signed)

July 26, 1884 A. VERNON HARCOURT

Since[1] the foregoing preliminary report was presented to the Board of Trade, the experimental inquiry has come to an end, and a complete account of the apparatus, observations, and testings has been published by the Committee of the Trinity House who had charge of the inquiry, followed by a statement of the conclusions at which the Committee have arrived.

I propose to arrange the remarks I have to offer under the following heads:—

I.—Apparatus for the exhibition of the experimental lights.
II.—Arrangements for observation.
III.—Photometry.
IV.—Comparison of lights.
V.—Range of lights in hazy weather.
VI.—Cost of each system.

I.—*Apparatus for the Exhibition of Experimental Lights*

In my preliminary report I have given a general description of the temporary towers, the lenses and lamps. In Parts I. and II. of the Trinity House Report are to be found plans and measurements giving the full details of these constructions. The towers are admirably suited to their purpose, and their situation and the distance between them proved most convenient for observation.

In regard to the arrangements for exhibiting the electric light, it is to be observed that, although the electric light completely outshone its competitors, it was heavily handicapped in the competition. The "leads" were not of sufficient calibre to carry the large electrical currents used, for a distance of nearly 300 yards, without considerable loss. Prof. Adams estimates the loss at more than one-fourth the electrical energy supplied.

The five vertical prisms used in the case of the electric arc to bring together the horizontal rays, subtended an angle of only 30°, while the annular lenses which served the same purpose in the gas and oil lanterns subtended an angle of 60°. Thus the fraction of the light emitted from the central source of light, which composed the revolving beam, was only half as great in the case of the electric arc, as in the case of the gas and oil flames. It seems probable also that a beam of less divergence may be used with advantage to obtain a maximum range in hazy weather; and such a beam may be obtained from the electric arc with lenses of moderate size. On a few occasions when an annular lens similar to those used in the other two lanterns was placed in front of the electric arc, the light was dazzling at a distance of more than a mile, and surprisingly vivid at a distance of 20 miles. I see that on a clear night when the 108-jet gas burner behind an annular lens gave a light of 60,000 candles, the electric arc behind its cylindrical lens and vertical prisms gave a light of 1,200,000 candles, and behind an annular lens a light of 12,000,000 candles. In the one case the arc was five times as powerful as Mr. Wigham's "quadriform," in the other fifty times as powerful.

For the sake of uniformity and comparison under similar conditions, only the central belt of the Fresnel apparatus was placed round the electric lamp as round the gas and oil burners. The suppression of the top and bottom prisms, though entailing a loss of 30 per cent. of the light produced, is a necessary sacrifice where large burners developing great heat are placed immediately one over the other. But each of the electric lamps in tower A might have been surrounded with a complete Fresnel apparatus, adding nearly one-third to their light, without any difficulty or any necessity for separating them more widely.

Thus, if the principle which has been enunciated had been followed, of doing for each illuminant the best that could be done within the limits of the lighthouse lantern, if a triform electric light had been exhibited, with leads of low resistance, with a lens subtending an angle of 60°, and with top and bottom prisms, the power of this light might have been more than tripled. By also reducing the divergence of the beam, which I think might be done with advantage, a further increase of power could have been gained. This fact should be borne in mind in comparing the results which were obtained with the three illuminants.

[1] Further Report of Mr. Vernon Harcourt to the Board of Trade on the Experimental Lights exhibited at the South Foreland.

In M. Allard's interesting and important "Mémoire sur les Phares électriques," 1880, he gives the results of a trial of three Gramme dynamo-machines and an electro-magnetic machine of the Alliance Company. The former gave for the same horse-power 40 or 45 per cent. more light than the latter. But M. Allard measured only horse-power and light, not the electrical energy developed; and it does not appear whether the larger yield of light was due to a more powerful electrical current, or to the position of the carbons, and the form of the incandescent ends, being more favourable to the emission of light with the continuous current. Probably the De Méritens machines, which produced a light of about 1000 candles per horse-power, are superior to those of the Alliance Company, which yielded only 540 candles, and are equal to the Gramme machines which yielded 800 candles per horse-power. Of all that relates to the economical production of powerful arc lights, knowledge is advancing rapidly. The ample provision of steam power, and the excellent photometric gallery at the South Foreland, will no doubt be used from time to time for the trial of new types of electrical machines, of regulators, and of carbons. For the past experiment, and apart from the question of cost, the De Méritens machines worked admirably, converting, according to the measurements of Prof. Adams, mechanical into electrical energy with a loss of only 16 per cent. The current supplied was more than sufficient for the largest carbons; indeed, carbons exceeding 1½ inches in diameter were heated to redness through their entire length.

In regard to the apparatus for exhibiting the gas system of Mr. Wigham and the oil lamps of the Trinity House, little can be added to the full and clear account of the Trinity House Committee. But as it has been stated, since the publication of the Trinity House Report, that Mr. Wigham's foreman was not left unfettered to make the best display which the apparatus in his charge would allow, I may here put on record what I saw and believe in the matter. I paid many visits to the gas lighthouse by day and by night, and was in frequent communication with the foreman, Mr. Higginbotham, from the beginning to the close of the experiments. The arrangement of each night's programme rested with the Committee of the Trinity House, who so ordered matters that abundant opportunity was given for the observation and measurement of all the varieties of each illuminant. Among these were Mr. Wigham's combinations of 28 jets, 48 jets, 68 jets, 88 jets, and 108 jets, the ready conversion of one of which into another is among the merits of his ingeniously constructed burner. When the effect of the smaller number of jets was to be observed, it is clear that the full power of the burner could not also be shown. Therefore, there were necessarily times when Mr. Wigham's foreman was not free to make the best display which the apparatus in his charge would allow. With this exception only, I believe that Mr. Wigham's foreman was perfectly free to do his best and make any improvements Mr. Wigham or he could devise. I see from the summary in the Trinity House Report that the full power of Mr. Wigham's burners was shown on 127 nights; and it appears from the photometric record that it was measured 57 times. This ought to suffice for an accurate judgment of its merits.

Comparing the gas and oil towers as they appeared to a visitor when in full operation, the gas had one striking advantage, and one equally obvious disadvantage. The advantage was that it needed no care. When the lenses had not to be revolved by hand, nor the number of jets changed, one attendant in the tower was sufficient, and he had little or nothing to do. In the oil tower, on the other hand, I have seen a keeper on every one of the three stages, each man watching and from time to time adjusting his lamp. The disadvantage encountered in the gas tower was the excessive heat from the large gas-burners, which by causing unequal expansion of the glass lenses and their metal framing, and of the outer and inner surfaces of the lenses themselves, caused cracks to appear, which in the continuous belt of thick glass gradually spread from side to side. But though the burning of gas yields for the same light more heat than the burning of oil, there is no reason to think that with a diminished consumption of gas, *e.g.* the 160 cubic feet an hour of the 68 jets instead of the 300 of the 108 jets, such a disaster would recur. When the gas flame is surrounded by a chimney, as in Sir James Douglass's and Mr. Sugg's multiple Argands, the heating of the lenses is greatly diminished.

When the lights were first exhibited, the behaviour of the oil lamps in C tower was a matter of much interest. Using gas, Mr. Wigham had succeeded in quadrupling the power of a large

burner behind a lens more than a yard square, by placing over it three other similar burners and lenses. But it seemed a hazardous experiment to imitate this plan by placing three lamps fed with mineral oil one over the other. However, the skilful arrangements of Sir James Douglass were completely successful. The three superposed oil lamps burnt as safely and well as if each had had the lantern to itself.

II.—*Arrangements for Observation*

A short account of these arrangements have been given in my previous report, and a complete account is to be found in the report of the Trinity House Committee.

The plans for making observations on shore at small distances had been well laid. The home at St. Margaret's, stationed between the two observing huts, with telephone to all points; the measured distances; the huts themselves, welcome refuges on a cold night, and most convenient for photometry with their helpful occupants; all bore witness to the wise forethought which had been bestowed upon the details of the inquiry.

For obtaining records of the relative brightness of the different lights from the impressions of those who saw them, probably no better plan could have been devised than that of distributing forms to be filled in with a numerical estimate of the ratio which two of the lights bore to the third. And the enlisting a multitude of observers, by the wide distribution of these forms, secured the two advantages, of an average drawn from a very large number of observations, and of an obviously impartial judgment. The observations made at sea from the Trinity House yacht *Argus*, which was in constant attendance, were of great importance; and I may add that, for the landsmen whose main business was photometry at small distances on shore, taking part in these observations was an essential help towards the full appreciation of the problem before them.

III.—*Photometry*

The chief assistance which I found myself able to render to the Committee was in devising and improving photometric apparatus and methods. A full description of these is given in the Committee's Report, especially in Mr. Dixon's "Record," part ii., pp. 30–36. During my visits to the South Foreland, I was principally occupied with photometry, in the dark gallery by day, and in one of the huts by night. Frequently Mr. Longford or Mr. Dixon worked with me, and the observations which I made are included in the general record. I believe that the standard of light employed was constant and of a definite and reproducible value, and that the methods of comparison were trustworthy and accurate. The excellent idea of Sir James Douglass, of using a large lens to concentrate the rays from the lighthouses upon the photometric disk, made possible the measurement in the more distant hut of lights whose intensity was too feeble to be accurately estimated without such aid. Mr. Dixon's polariscope photometer and the ingenious obscuration photometer of Captain Nisbet, are instruments well adapted for the direct comparison of distant lights or lights enfeebled by haze; the former can only be used for lights which are near together. Two movable photometer-bars, designed by Sir James Douglass, and suitable for use with any form of disk and any standard, were in constant employment throughout the trial. These were placed in the photometric gallery and in hut II. The observations in hut I. were reduced by means of a portable bar devised and made by Mr. Dixon.

A glance at the 16 columns of the closely-printed photometric record,—each number being, as a rule, the average of many observations,—will give to those who know the effort of attention which accurate photometry requires a conception of the diligence with which this branch of the inquiry was pursued. I have spent many hours in one or other of the huts with Mr. Dixon or Mr. Longford, and I wish to express my conviction that the results which they obtained and which are printed in the Trinity House Report, are as complete and trustworthy as zealous, patient, and skilful work could make them.

IV.—*Comparison of Lights*

Although an observer's opinion on the relative brightness of two or more lights, like an opinion on the force of the wind, is better expressed by means of numbers than by descriptive terms, such numbers must not be regarded as expressing the relative intensity of the lights so compared. Perhaps on any future occasion it would be better to call the brightest light 10 rather than 100, since the use of the larger number suggests that an inferiority just sufficient to be noted with confidence is to be expressed by a difference of 2 or 3 per cent., whereas it probably amounts to at least 10 per cent., and 9/10 or 8/10 would be nearer the ratio of the two lights than 98/100 or 95/100. No doubt by practice in comparing lights whose relative intensity is known, a fair power of judging may be acquired; but without such training the natural tendency is to under-estimate differences. For example, the average of 294 estimates by eye of the relative power of "triform oil" and "quadriform gas," assigns to the gas a superiority of 6 per cent., whereas the actual superiority as shown by measurement is 23 per cent. According to the same series of estimates the electric light has a superiority over "quadriform gas" of 59 per cent., the actual superiority being more than 400 per cent.

Equally remarkable evidence of the tendency to overlook differences of intensity when the estimate is made directly by eye, is found on comparing the values assigned to "multiform" lights. The figures relating to the 108-jet gas-burners, and representing the relative value of the single, biform, triform, and quadriform lights, each by comparison with the electric light, are 56, 61, 59, and 63. If these numbers represented the intensity of the light falling upon the eye from the whole surface of the illuminated lenses, they should stand in the ratio of 1, 2, 3, and 4. The explanation at once suggests itself that while the photometer measures the total light received from a large illuminated surface, the eye judges of the brightness of the surface or the light received from equal areas. To an observer looking down a street on a clear night, the more distant gas-lights seem as bright as those which are nearer, though smaller in size; if asked to estimate the lights he would probably assign the same figure to all. And the visual angle subtended by the flame of a street-lamp at 100 yards is about the same as that subtended by 18 feet of lenses at a distance of 4 miles. The singular fact that as estimated by eye, on a separate comparison with the electric light, "multiform" have no superiority to single lights, may to a small extent admit of the explanation which applies to the familiar case which has been given. In this case the observer distinguishes between size and brightness, and sets himself to judge of the latter only; or it may be that the intensity of the sensation of light depends upon the brightness and not the size of the spot of light formed upon the retina. But the South Foreland observations were not made chiefly at distances of only 2 or 3 miles; nor were the observers likely to disregard the apparent magnitude of a light in estimating its value. At distances of from 12 to 14 miles, at which the largest lights have no appreciable magnitude, the average values assigned to the biform, triform, and quadriform lights are 75, 66, and 60.

I fear the true explanation is that the results have suffered from the electric light having been adopted as the term of comparison. To a small extent its fluctuations and difference of colour, and to a much greater extent its incomparable power, have made the estimates entirely uncertain; and thus it is vain to institute cross comparisons between the different lights which were not seen together, but only estimated by reference to the electric light as a standard. This conclusion, however, does not affect the value of the comparisons, chiefly aimed at, between the gas and oil lights, which were seen together, nor the significance of the direct comparison of the flame lights with the electric light at all distances and in all weathers. Indeed, the adoption of the electric light as the standard with which all others were to be compared, has served to establish on the basis of thousands of observations the important fact that, as far as the eye can judge, the electric light appears to excel the light of gas or oil lamps almost as much at greater as at smaller distances, and in hazy weather as in clear. The mean ratio of the electric light to all the gas and oil lights exhibited, taken from the whole number of recorded observations, is, at distances of from 1 to 8 miles 1000/626, at distances of from 8 to 15 miles 1000/613. In clear weather the mean ratio is 1000/591; in weather not clear it is 1000/608.

The photometric record presents many points of interest.

In the measurement of naked flames the long gallery, which has wisely been made a permanent structure at the South Foreland, afforded unexampled facilities. The electric arc was measured at a distance sufficiently great for its intensity to be similar to that of the other lights which were measured. The values assigned to it, from 10,000 to 15,000 candles, are not so high as some which have been obtained; but this is perhaps due to the fact that extreme values were rejected, and care was taken to obtain an average result.

In one respect the observations are incomplete, and need to be supplemented at some future time. Within the lighthouse the source of light is surrounded by an apparatus which gathers together the light sent forth in all directions, excepting a small angle above and below. Thus, the intensity of the light sent in a sloping direction upwards and downwards is of as great importance as that of the light sent forth in the horizontal plane. But only the latter has hitherto been measured in the photometric gallery. According to M. Allard the electric arc produced by an alternate current sends out horizontally an amount of light which is 11 per cent. greater than the average amount sent in all directions. With a continuous current the strongest light is thrown on the side opposite to the positive carbon; but it happens that with an arc light of this description horizontal measurement gives the average value. Probably Mr. Wigham's wide cluster of gas jets sends forth less light horizontally, owing to the imperfect transparency of one flame to the light of another, than it sends in an upward direction; and the same may be the case with the concentric gas-burners and oil lamps. Mirrors might hereafter be arranged within the photometric gallery, which would serve for making these measurements.

To determine accurately at a distance the power of the various lights exhibited was an essential preliminary to calculating the range of any of the lights in hazy weather. And although this power is approximately calculable, the power and dimensions of each flame, and the structure of each lens being known, it was of great interest to make actual measurements of the intensity of the light at two different points, and in different states of the atmosphere. I am not aware that such measurements had ever before been attempted. Owing to the novelty of the photometric problem, and to some extent of the methods employed, it was highly important to have some means of testing how far the results were trustworthy. Such means were furnished by the multiform system of Mr. Wigham. At any distance, and in any state of the atmosphere, the illumination produced by a combination of two or more similar lamps and lenses is so many times as great as the illumination produced by a single lamp and lens of the same kind. Thus, among the lights to be measured were several whose relative power was known beforehand. If testings of single and multiform lights, made in succession while the degree of clearness of the air was unchanged, gave values varying approximately as the number of lights, an equal degree of exactness may be ascribed to the testings of other lights and lenses.

On July 12, the weather being "clear, calm, overcast," the light from the single, biform, triform, and quadriform 108-jet burners, showing through Mew Island lenses, was measured at hut I. The results in thousands of candles were 50, 98, 168, and 214. Three testings intervened between the second and third, and probably the air had become a little clearer, but the numbers are not far from the ratio 1, 2, 3, 4. Three days later the same single, triform, and quadriform combinations were tested one after the other, also at hut I. The values found are 48, 145, and 186. Similar testings were made on July 23, on a clearer night, of all four combinations; their power was found to be 58, 112, 171, and 220 thousands of candles. Probable values in the ratio of 1, 2, 3, 4, are 56, 112, 168, and 224. On the same night the value found for a single six-wick oil lamp behind an Eddystone lens was 56,000 candles, and for three such lamps behind three such lenses 168,000 candles. On November 1, in thick haze, the value found at the nearer hut for "I. Gas, 108, M.," was 25,500 candles, and for "IV. Gas, 108, M.," 102,000. The results obtained at hut II., with a wholly different photometer, are confirmed in the same manner. For example, on February 7, consecutive testings on a misty night of "single" and "quadriform gas" gave in thousands of candles the numbers 26 and 101. On March 20, on a very clear night, the values found for the same two lights were 63 and 252.

In looking over the tables of the photometric record, and comparing the figures standing against combinations of equal numbers of oil lamps behind Eddystone lenses, and of the larger gas-burners behind Mew Island lenses, in all weathers in which the lights were measurable, the eye is struck by the similarity of the numbers. The rival systems are nearly equal; there is little to choose between them. Still less difference, as has been pointed out, was discernible on looking, as we did night after night, at the lights themselves. Other considerations than that of visibility in either clear or hazy whether, must decide which, if either, of the two systems is to be generally adopted for lighting our coasts. By multiplying burners and lenses, and by enlarging the size of the lenses, more powerful lights still may be produced, if it is thought desirable, with either illuminant.

But the most prominent fact on the face of the photometric record is the immense superiority of the electric light. The conclusion forces itself upon the reader of these tables that if greater power is needed, it is to be found, not by magnifying lenses or multiplying combinations of gas or oil burners, but by substituting the light of the electric arc.

The Trinity House Committee report that the electric light in clear weather is certainly not popular with sailors, chiefly on account of its dazzling effect at short ranges. But at ranges exceeding two or three miles, "hyper-radiant," or even multiform lenses, are not visibly larger than such a lens as is suitable to the electric arc; and at such ranges the "dazzling effect" is simply that due to the power of the light. If a double quadriform were as powerful it would dazzle as much. Also the use of a powerful electric arc in clear weather may be avoided. It would not be difficult to arrange for the use of a small electric arc during clear weather, and the quick substitution of a powerful arc light when the weather became hazy. I would venture to suggest that the singular circumstance which led or contributed to the removal of the electric light at Dungeness, that a vessel went ashore near the lighthouse, may have been due, not to the dazzling effect of the light, but rather to the diminution of brightness as the approaching vessel passed within and beneath the range of the light. With the condensed and sharply-defined beam of the electric light, it may perhaps be desirable to devote some part of the optical apparatus to spreading a portion of the light over the space intervening between the coast and the point, a mile or two away, at which the principal beam first strikes the sea. If this is done, the light at short ranges might be made sufficient, but not too dazzling; and for longer ranges there seems to be no reason why the powerful beam produced by the electric arc behind one of the Mew Island lenses should not be employed. This beam had a divergence of about 1°. Even from the high level of the South Foreland lights, if the axis of such a beam were so inclined that only about $\frac{1}{6}$ of the light passed over the horizon, the full light would extend to within about three miles of the shore. Since the apparent brightness of every light must vary with the state of the atmosphere, as well as with the distance of the light, and as the angle subtended, even by a multiform light, at a few miles distance is very small, it cannot be possible by the appearance of a light without other data to judge of its distance. The electric light is not singular in this respect.

(*To be continued.*)

THE LUMBAR CURVE IN MAN AND APES

We are indebted to Prof. Cunningham, of Trinity College, Dublin, for a well-illustrated and exhaustive memoir on the subject of the lumbar curve in man and apes. This memoir has been printed by the Royal Irish Academy as one of the Cunningham Memoirs, and is illustrated by thirteen plates, several of which are large folding ones, and two of which are large coloured drawings of the two surfaces of a mesial section of a male chimpanzee; these are life-size, and are the first accurate representations of the topographical anatomy of this anthropomorphic ape we have seen.

The structural differences between man and the anthropoid apes are no doubt in a great measure due to the assumption by man of an erect attitude, and to his having from an early period of his life dispensed with the use of his anterior extremities as organs of locomotion. The vertebral column of man might be expected to exhibit in a marked degree differences distinguishing it from other animals, and that more or less deep convexity forwards in the region of the loins has been considered by some not only as a marked character of the human spine but even as peculiar to humanity; other anatomists have denied that this is so, and consider that man and certain of the man-like apes have it in common. In this memoir Prof. Cunningham seems to minimise the importance of the lumbar curve as a distinctive character of any special group. Not only the higher, but also the majority of the lower apes, possess this curve; and, under

certain conditions, even some quadrupeds show clear traces of it. In the course of his investigations, Prof. Cunningham has brought many new and interesting facts and phenomena to light. Thus in man and the chimpanzee the quality of this lumbar curve is identical; the only differences are its extent and its development. And then among the members of the human race this curve does not appear to be equally prominent; upon some —as the Australian, the Negro, and the Andaman Islander —the curve is by no means so well marked as it is in the European. Not that the absolute degree of curvature is less in these races, but whereas in the European the bodies of the vertebræ are more or less moulded in adaptation to the curve, in the lower races there is to be found no trace of this. With this subject the first part of this memoir is taken up, and the adaptation of the vertebral bodies with reference to the lumbar curve is considered in a first section. The method of making the measurements, and the results derived from them, are given, and special points in connection with the European and several of the lower races (Australian, Tasmanian, Andaman, Negro, and Bushman) are given. Then follow details of the indices of the lumbar vertebræ in the four man-like apes, as well as in nine of the lower apes. The statement that this curve is more marked in the female than in the male is strongly supported by the evidence adduced in this memoir, and it would seem that the vertebral bodies of the female are moulded more in adaptation to the curve than those of the male.

The second section of this part of the memoir treats of the entire lumbar curve as found in man and the apes. The difficulties in the way of securing accurate curvatures of the living spine seem to be insuperable. Parow, who worked hard on this subject, has signally failed; hence the standard of comparison must be sought for in the dead, and the details of how this has been done are given at some length. Racial differences are next discussed, and the development of the spinal curve is treated at great length, with some excellent illustrations. The condition of the lumbar column in the anthropoid apes is next considered. It was, as we have seen, thought that the lumbar curvature did not exist save in man. Goodsir is positive about it. Sir W. Turner at one time was equally so. Sir Richard Owen denies its presence in the gorilla and orang-utan. Huxley was among the first to assert its existence. Broca and Topinard followed. As to the facts to be seen by frozen sections, Cunningham has not succeeded in getting fresh material for the gorilla; but in the case of the chimpanzee the curve differs but little from that in man. In the orang it is feeble, resembling that in man in some respects, and in others differing from that in the chimpanzee. In a gibbon (*Hylobates agilis*) it stands intermediate between the chimpanzee and orang. In some of the monkeys it is also to be found, and even in some quadrupeds.

In a second part of his memoir, Prof. Cunningham, taking advantage of the same anatomical method which enabled him to make such interesting discoveries as to the extent of the curves of the vertebral column, viz. by sections through recently frozen bodies, has been able to advance our knowledge of the topographical anatomy of the orang, chimpanzee, and gibbon, very considerably. Certain relations of distinct morphological importance cannot by any other method be with accuracy ascertained. The question of how far the cerebrum in the anthropoid apes projects backwards in relation to the upper surface of the cerebellum, was at one time a burning question, and, although fairly set at rest, cannot be said to have been unmistakably demonstrated until now; when the whole of the parts were frozen in their places, sections were made, and we have the results in this memoir amply corroborating previous inductions. Sections of the brain *in situ* in the adult male and newly-born child, in the male and female chimpanzee, female orang, and gibbon, are all figured. Other points in the anatomy of the brain, as the condition of the corpus callosum, and of the hippocampus minor are also alluded to, and a few further details as to other visceral anatomy are given.

The memoir forms a quarto volume of some 150 pages, the typography of which is extremely creditable. The woodcut illustrations and plates are excellent, and the publication of this treatise as a Cunningham Memoir marks the appreciation of its value by the Council of the Royal Irish Academy, as the series of its publication—known as the Cunningham Memoirs, because the expenses thereof are defrayed out of the funds left by a Mr. Cunningham—is reserved only for works which the Council believe contribute some new facts to science.

SCIENTIFIC SERIALS

Bulletin de l'Académie Royale de Belgique, August.—Note on the eruptive rocks of the islands of Marion, Prince Edward, Macdonald, and Heard, by A. F. Renard. These insular groups, which stand on the great submarine plateau in the southern regions of the Indian Ocean, are shown to be entirely volcanic, in no way connected either with the Madagascar group or with the lands of the South Polar seas. Marion and Prince Edward, which were visited and partly explored by Mr. Buchanan, of the *Challenger* Expedition, consist of old plutonic formations, such as feldspar basalts and much more recent black and other lavas. Heard, discovered in 1853 by the American captain Heard and also visited by the *Challenger*, is largely covered with a black volcanic sand formed of grains of magnetite and augite. Elsewhere occur more recent lava formations, which show no trace of the erosive action exercised by the sands on the older rocks. All the specimens collected here belong mainly to the group of feldspar basalts.—On the presence in Belgium of *Bothriocephalus latus*, Bremser, by Edouard van Beneden. A few recent instances are recorded of the presence in Belgium of this human parasite, which is common enough in Holland.—Experimental researches on the influence of magnetism on the phenomenon of polarisation in dielectrics, by Edmond van Aubel. In this second communication the author gives the result of fresh experiments, showing how, by means of a specially-constructed electro-magnet, the electric field which interfered with previous researches may be completely eliminated, while preserving an intense magnetic field. The electro-magnet here described may also be used in ordinary physical experiments, wherever it is necessary to ascertain whether the phenomena observed with the Ruhmkorff and other electro-magnets are due to magnetism and not to the electric field or to the heat of the current traversing the bobbins.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, November 2.—M. Jurien de la Gravière, President, in the chair.—Fresh communication on rabies, by M. Louis Pasteur. (For summary of this report, see p. 30).—Note on the unequal flow of gases, by M. Haton de la Goupillière. Having, in previous papers, given a complete analytical solution of the various problems connected with this subject, the author here determines the true character of his formulas in their relation to experimental applications.—Remarks on M. Fontaine's report concerning his experiments on the transport of power by electricity, by M. Marcel Deprez. It is pointed out that M. Fontaine's method, which replaces the generator and receiver by a series of machines coupled together in sufficient number to produce the desired effect, so far from being based on any new principle, is the same as that proposed by all electricians who have sought to obtain high tensions without having recourse to the construction of the special machines first suggested by the author. The means employed by M. Fontaine to control simultaneously the four series of generators is also stated greatly to resemble that described in a patent taken out on April 28, 1885, by M. Deprez.—Experimental researches connected with the cerebral functions, by M. Brown-Séquard. These researches have been undertaken in order to show how varied and numerous are the purely dynamic effects proceeding from influences exercised on the encephalon by the sensitive nerves, and on the motor nerves by the nervous centres. Experiments carried on for seven or eight years lead to the general conclusion that all the motor nerves, and nearly all the excitable parts of the nervous centres, may have their excitability greatly modified, even under the influence of remote and slight irritations of the greater part of the nervous system.—On the atomic weight of the oxide of gadolinium, by M. A. E. Nordenskjöld. This compound is not a simple oxide, but consists of the three closely-related oxides of yttrium, erbium, and ytterbium, all with very different atomic weights. Nevertheless, even when derived from quite different minerals occurring in localities far removed from each other, it is here shown to possess a constant atomic weight. On the other hand, this substance is not a true chemical combination, but an isomorphous mixture, thus presenting a new phenomenon in chemistry and mineralogy. It is the only known instance of three isomorphous substances of the class which must still be regarded as

elements that are found in Nature not only always together, but always together in like proportions. — On a new function of the otocysts in the invertebrates, by M. Yves Delage. A long series of researches recently conducted at the laboratory of Roscoff leads to the conclusions that these organs, occurring chiefly in the higher crustaceans and mollusks, serve not only as organs of hearing, but also, and perhaps mainly, as organs of locomotion, thus corresponding to the labyrinth of higher animals.—On *Gymnodinium polyphemus*, P., by M. Pouchet. Although hitherto regarded as a member of the vegetable kingdom, this organism presents the remarkable peculiarity of possessing an organ of vision of a somewhat complicated type. It is a headless Peridinian, occurring on the French coast, and, like all Peridinians, feeds on vegetables by endosmotic absorption. The eye, which always occupies a uniform position, is formed of two parts—a true crystalline and a true choroid—and its real character cannot be mistaken, resembling, as it does, in the most striking manner, the eyes of certain worms and Turbellariæ.—Saturation of selenious acid by the bases, and acidimetric analysis of this acid, by M. Ch. Blarez.—On the heat of neutralisation of the homologous or isomerous monobasic acids, by MM. H. Gal and E. Werner. The heat of neutralisation, already determined by Berthelot and Louguinine for formic, butyric, and some other fatty acids, is here determined, together with the heat of dissolution for others, such as isobutyric, isopropylacetic, trimethylacetic, caproic, &c.—Synthesis of pentamethylenediamine, of tetramethylenediamine, of piperidine, and of pyrrolidine, by M. A. Ladenburg.—On two new chlorurretted derivatives of methylbenzoyl, by M. Henri Gautier. The process is explained by which the author has obtained a trichlorurretted and a bichlorurretted methylbenzoyl.—A new reaction of the chloride of aluminium: syntheses of the fatty series, by M. Alph. Combes. The chloride of aluminium, which has effected so many syntheses in the aromatic series, is here for the first time systematically applied to the production of substances of the fatty series.—Hæmatoscopy, a new method of analysing blood, based on the employment of the spectroscope, by M. Hénocque. This method, already tested on 200 subjects, comprises two classes of observations: (1) determination of the quantity of oxyhæmoglobin, or active colouring-matter of the blood, by means of instruments here figured, and named "hæmatoscopes" and "hæmatospectroscopes"; (2) duration of the reduction of the oxyhæmoglobin estimated by spectroscopic examination.—Fresh remarks on the stem of Poroxylon, a fossil Gymnosperm of the Carboniferous epoch, by MM. C. Eg. Bertrand and B. Renault. By comparing together homologous sections of stems of the same order but of different periods, the authors have succeeded in determining the variations introduced by time into the normal stem of this plant.—On a fundamental condition of equilibrium for the living cells of plants, by M. Léo Errera.—Petrographic study of a carboniferous diabase from the neighbourhood of Dumbarton, by M. A. Lacroix. The rock here under consideration, a vertical greenish stratum traversing the old red sandstone, presents an opportunity of studying in a small space the various structural forms which a volcanic rock may assume under the influence of a progressive cooling process. —The dislocations of the globe during recent periods, their lines of fracture, and the conformation of the continents, by M. Jourdy.—On the unity of forces in geology (continued), by M. H. Hermite. It is argued that simple oscillations of sea-level, produced by meteorological causes, would suffice, without having recourse to internal agencies, to explain the *apparent* oscillations of the land in relation to latitude, which are characteristic of the Quaternary epoch.—On the pathologic physiology of the supra-renal capsules, by M. Guido Tizzoni.—On the contractions determined by the currents of polarisation of the living tissues, by MM. Onimus and Larat. The experiments here described place beyond doubt the existence and energy of the currents of polarisation in our tissues, thus exposing the errors of the fundamental experiments carried out by Du Bois-Raymond and most German physiologists.—Note on a remarkable substance collected at Luchon on July 28, 1885, after the fall of a thunderbolt, by M. Stanislas Meunier.

STOCKHOLM

Academy of Sciences, October 14.—Contributions to the anatomy and histology of the limnivore Annelids, by Dr. A. Wirén.—On the electric nature of drift-snow, by Prof. A. Holmgren.—On the work and activity of the Ornithological Committee of the Academy for studying birds of passage, &c., by Prof. F. A. Smitt.—On new acquisitions to the Botanical Garden of the Bergian donation, by Prof. V. Wittrock.—On the lichens of the islands of the west coast of Sweden, by Dr. P. Hellborn.—Contributions to the anatomy of the Marcgraviaceæ, by Hr. H. O. Juel.—Studies of the influence of woods and forests on the climate of Sweden, by Dr. Hamberg.—On remains of Dryasoctopetala, L., in calcareous tuff near Vadstena, by Prof. A. G. Nathorst.—On combinations of phenylmethyl-triazol, by Hr. J. A. Bladin.—On the orbit of the comet 1877, VII., by Dr. R. Larsén.—Demonstration of the proposition that the complete integral of differential equations of the *n*th order contains *n* arbitrary constants, by Dr. G. Eneström.

BOOKS AND PAMPHLETS RECEIVED

Chemical Arithmetic, 2nd edition: S. Lupton (Macmillan).—Charter, By-Laws, and List of Members of the Institution of Civil Engineers (25, Great George Street).—Minutes of Proceedings of the Institution of Civil Engineers, vols. lxxxiii. to lxxxvi (25. Great George Street).—Lectures and Essays, 2nd edition: W. K. Clifford (Macmillan).—The Rotifera or Wheel Animalcules, part 6: C. T. Hudson and P. H. Gosse (Longmans).—Calendar of University College of North Wales, 1886-87 (Cornish, Manchester).—Persia as it is: Dr. C. J. Wills (S. Low).—High Life and Towers of Silence: Mrs. Fred Burnaby (S. Low).—Smithsonian Report, 1884, part 2 (Washington).—Proceedings of the U.S. National Museum, vol. viii., 1885 (Washington).—Practical Dynamo-Building: F. W. Walker (Iliffe and Son).—Journal of the Royal Agricultural Society, October (J. Murray).—Rendiconto dell' Accad. delle Scienze Fisiche e Matematiche, anno xxii., xxiii., xxiv., 1883-84-85; anno xxv., fasc. 1, 2, 3 (Napoli.)—Nature Musings on Holy-days and Holidays: Rev. N. Curnock (Woolmer).—Commercial Organic Analysis, vol. ii.: A. H. Allen (Churchill).—A Synopsis of Elementary Results in Pure Mathematics: G. S. Carr (Hodgson).—Our Temperaments: A. Stewart (Lockwood).—The Coming Deluge of Russian Petroleum: C. Marvin (Anderson). — Methods of Analysis of Commercial Fertilisers (Washington).—Publications of the Leander McCormick Observatory of the University of Virginia, vol. i., part 3, Nebula of Orion, 1885.

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